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Do Birds Return to Agricultural Landscapes through Adoption of Natural Farming Practices? A Comparison of Natural Farming vs. Chemical Farming in Andhra Pradesh

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Abstract

The global decline in farmland bird populations in India is often ignored. The overuse of agrochemicals in farming is the root cause of all these catastrophic results. There is ample evidence in the literature that transitioning to agroecological practices may reverse this trend. We anticipated that the bird population visiting natural farming-Andhra Pradesh Community managed Natural Farming (APCNF), a novel farming approach popular in India, will increase. The study used **nested design** to compare the number of bird visitations in natural farming versus chemical farming to determine whether natural farming can enhance the bird numbers and diversity. Furthermore, we analyzed the bird species visits to natural and chemical farms in different agroecological zones in Andhra Pradesh, the southernmost state of India. We used the point count survey approach to count the birds on comparable farms. MANOVA and non-parametric analysis are used to examine the findings. The bird species were ranked using a Likert scale. The results show that the average bird population visiting natural vs. chemical farms varies significantly at the 0.05 level of significance, and the bird species visiting both natural farming fields and chemical farms varies between geographies and time interval.

Keywords

Bird Population, Natural Farming versus Chemical Farming, Andhra Pradesh, India

1. Introduction

Birds help farmers besides predating insect pests that attack their crops and by pollinating flowers. There is a strong link in nature between bird populations and agricultural landscapes. Agricultural land provides food and habitat for birds, and birds help the farmer with pollinating and pest management services. Bird populations in agricultural landscapes are an indicator that the landscape has the most biodiversity and is being managed in a sustainable way [1]. According to a 2018 report released by International Union for Conservation of Nature (IUCN), 100 of India's 1312 recorded bird species are threatened, with 17 of those being critically endangered, 20 of those being endangered, and nearly 63 of those being vulnerable [2]. Changes in land management and use of synthetic fertilizers have been cited in literature as the primary cause for the decline in farmland bird populations [3] Recent bird population data shows that 867 native bird species are on a decline in India [4]. This information could be a wake-up call for everyone to act quickly. Another study describes this as a man-made disaster, citing the widespread use of agrochemicals in agricultural landscapes as a contributing factor [5]. The decline in bird populations is related according to 42% of the studies, to the use of agrochemicals in the ecosystems while 27% point to habitat destruction as a cause [6]. The good news is that these changes are reversible if agricultural production is maintained, and chemical pest control methods are replaced with biological ones.

Another major reason for bird population decline in India is that several counterfeit and banned agrochemicals are used in both domestic and agricultural settings, which has a greater impact [7]. Studies reveal that pesticides, in addition to killing birds, also harm reptiles and beneficial insects, all of which are critical components of a crop's ecology [8]. Therefore, a wide range of birds, such as *Drongo* and pollinators, have been pushed out of their native habitats by human activities. It is projected that the "baya" and the house sparrow will soon go extinct in India's agricultural landscapes, according to recent studies [9]. Apart from this, other research shows that chemical residues in seeds are a major concern for seed-eating birds [10]. Elevated levels of the pesticide neonicotinoid, particularly imidacloprid in agricultural surface waters and seeds, are a direct link between decline in local bird population and imidacloprid in the environment that requires immediate action [11]. Over the past few decades, overuse of granular pesticides in the paddy environment and certain seed treatment chemicals have resulted in the extinction of various species (birds, reptiles, and amphibians) associated with agricultural ecology [12]. However, it is reported in the literature that only five of the 1000 species found on agricultural crops in India cause crop damage, which is extremely low [13]. Considering this, why are birds portrayed as enemies of farmers when only a small number of birds damage crops? It's important to note that conflicts over intensive agricultural practices and farmland birds continue to erupt all over the world [14]. To summarize, agricultural intensification has been linked to a significant decline in bird populations [15]. It is of vital importance to reconcile bird species diversity and conservation measures and strategies for conserving bird population in and within agricultural landscapes. The catastrophic state of the bird population reduction raises the question of implementing novel farming methods that have the maximum potential to improve biodiversity and ecological services in and around agricultural landscapes [16].

Natural Farming: A Novel Farming Approach

Many agricultural practices are recognized around the world to conserve bird populations and improve habitat. Natural farming techniques are closely related to agroecological production systems that use non-synthetic inputs to increase farm productivity and health while reducing direct costs [17]. These practices reflect a peasant movement in India, particularly in Andhra Pradesh, that follows the concept of *farming in harmony with nature*. This production system is popularly known as *Andhra Pradesh community Managed Natural Farming* (APCNF) in Andhra Pradesh and is currently a widely practiced as part of modern climate agroecology [18]. Natural farming practices improve soil organic matter content, functional microbial diversity, water holding capacity, and pest-predator populations without the use of synthetic fertilizers or pesticides by utilizing the principles of biological nitrogen fixation and the integration of livestock and species-rich plant communities [19]. Furthermore, natural farming is based on the idea of covering the soil with 20 - 25 crop varieties annually [20]. These universal principles of natural farming techniques such as covering the soil all over the year to keep the living root in the soil, minimal disturbance to the soil, bio-stimulants as necessary catalysts, diverse crop trees, more organic residues in the soil, pest control through plant extracts, including the use of fermented products such as solid and liquid Jeevamrutham would therefore increase soil porosity and the carbon sponge, which also will increase native earthworms [21]; as the carbon sponge grows, so will the soil's microbial diversity. Beejamrutham seed treatment protects the seed from harmful microbes as it is produced entirely naturally from cow dung and urine and stimulates the activation and growth of beneficial latent soil microorganisms [22]. Microbes produced in the soil following seed treatment with Beejamrutham will mobilise nutrients and break down organic materials [23]. The Andhra Pradesh Community Managed Natural Farming (APCNF) initiative was launched in 2015 and has so far influenced 800,000 farmers, with the goal of reaching all six million farming families in the long run. Natural farming cultivation practices such as multiple crops, no agrochemicals, and mulching are used to significantly minimize production expenses [24] and reports show that this approach of farming contributes to the achieve the Sustainable Development Goal [25]. Low-intensity farming approaches have been shown to reduce the harmful impacts of agricultural intensification on birds [26]. These approaches protect birds from chemical exposure and help to prevent a decline in bird population [27]. The return of birds to agricultural landscapes in India after farmers stopped using pesticides has been shown in several studies [28]; the research demonstrates that adopting alternate farming techniques have higher bird population density than chemical farms [29]. It was found that maintaining near-natural habitats near agricultural landscapes increases the number of birds and beneficial insects, pollinators, and has a good influence on bird populations [30]. In India, natural farming practices are gaining traction as a viable alternative to chemical farming and all practices of natural farming such as installing perches for birds and planting border strips of crops in agricultural areas, there may be an increase in bird habitat [31]. With this in mind, we believe that like other best alternative agricultural practices, natural farming has better potential to attract more birds than chemically farmed fields [32] [33]. Since natural farming turns out to be the best alternative approach in terms of its unique farming approach, this study seeks to compares the number of birds returning to natural farmlands with those returning to chemically farmed lands.

- The study seeks to untangle the differences in the number of birds visiting natural farming (APCNF) compared to chemical fields in different agroecological zones of Andhra Pradesh.
- The study assumes that there could be spatial and temporal variations in different agroecological zones in Andhra Pradesh in terms of number of birds visiting APCNF and Chemical fields.
- To better understand the bird species, visit natural and chemical farms.

2. Material and Methods

2.1. Study Area and Data Collection

In this study, we chose the southernmost state of India, Andhra Pradesh, as the study area. The reason for this study selection is that the state has become an important centre of natural farming and farmers are increasingly adopting these practices [34]. We conducted the study for 3 months (July-September) to 2019, during the first farming season. We have selected ten natural farming farms in each agroecological zone and compared them with ten chemical farms and ensured sufficient isolation to avoid spill-overs [35]. The study selected different agroecological zones to compare bird populations visiting different farming systems. Agroecological zones are defined by similar physiography, climate, cropping patterns, soils, and irrigation resource development [36]. Agroecological zones are classified based on rainfall, soil type, and crop intensity in Andhra Pradesh [37]. We have selected five agroecological zones in Andhra Pradesh based on rainfall, cropping intensity, soil type and input use in this study. To briefly elaborate them: 1) The north-coastal zone: this zone covers the districts of Srikakulam, Vizianagaram, Visakhapatnam, and receives an annual rainfall of 1060 mm where the main crops are paddy, millets, sesame, black gram, Maize and horticulture crops. In this zone moderate use of agrochemicals with high tree density; 2) The Godavari zone is characterized by overuse of water, agrochemicals, and farmers largely dependent modern technologies in farming dominated by deltaic alluvium, red clay soils, and red soils with annual rainfall between 1000 mm. 3) Similarly, the Delta zone comprises districts like Krishna and Guntur, which produce key commercial crops like cotton, chilli, rice, and maize, with an annual rainfall of 800 - 1000 mm and largely alluvial, black cotton soils. 4) Moreover, districts like Nellore, Chittoor, and Prakasam are located in the Southern zone, which receives 700 - 1050 mm of rain annually. About 60% of the rainfall is during North-East monsoon. The main crops are paddy, peanut, pulses, sugar cane, and millets with soils types ranging from red, laterite soils and black cotton soils. 5) Anantapuram, Kurnool, Kadapa, and parts of Prakasam are among the districts under scarce rainfall zone. The main crops grown here are peanut, black gramme, red gram, cotton, and chillies, with soils ranging from red loamy to black cotton. 6) The sixth zone is the high attitude and tribal zone, which encompasses forest regions in the districts of Srikakulam, Vizianagaram, Visakhapatnam, and East Godavari and is situated at high elevations with increased tree density, forest cover, and an annual rainfall of 1400 mm. We confined to five agroecological zones in Andhra Pradesh and identified 10 farm pairs in each zone (**Table 1**).

The data was collected through agricultural science graduates working with Rythu Sadhikara Samstha (RySS), which means for "farmer empowerment cell" in English. The RySS is a state government initiative in Andhra Pradesh to promote natural farming. The agricultural graduates were trained in bird population surveying techniques. The information was gathered from farms in the same village adopting natural farming versus chemically treated farms. The study used *point-counting approach* to the birds at different times of the day [38]. The agricultural graduates who work at RySS were taught how to count birds while standing at the edge of the field in all geographical locations. The minimum farm size for data collection in the comparable farms was one acre. To minimise duplicate counting of birds in the research, we took adequate procedures. We counted birds in the second farm pair, for example, from the opposite way as the first farm pair. The counts were done multiple times throughout the day, including twice in the morning (6:00 am and 8:00 am) and twice in the evening (4:00 pm and 6:00 pm). We used the **point count approach** that allows the researcher to sit in one place and count the bird species at various times of the day in both natural farming and chemical fields as our primary purpose was to measure the number of birds visiting different farming systems, where the birds might fly or stand in various places [39]. In addition, to help identify the bird species, we developed a list of the most common bird species that visit agricultural areas and photographed them throughout the survey. We created a questionnaire using the Likert scale to categorise the species present on similar farms. We listed the most frequent bird species found on field trips and recorded them in the literature. There is a dearth of extensive study on the most common species of Indian birds in terms of population structure and dispersion; nevertheless, some studies on seasonal variations in population density and other indicators of a few

Table 1. Different agroecological zones selected for the study in Andhra Pradesh.

S. No.	Agroecological zone	Natural farming	**Chemical**	**Crops**	**Rainfall in milli meters**
1	North-coastal	10	10	Paddy, Millets	1060
2	Godavari	10	10	Paddy	1000
3	Delta zone	10	10	Cotton, Chillies	800 - 1000
4	Southern zone	10	10	Paddy, Chillies	700 - 1050
5	Scarce-rainfall zone	10	10	Groundnut, Pulses	500 - 750
	Total	50	50		

species in agricultural settings have been done [40]. Various common bird species identified from the literature in agricultural landscapes of India includes common mynah [41], rose-ringed parakeet [42], egret [43], sparrows [44], crows [45], Indian rollers [46], quail birds, baya weaver birds, red vented bulbul, ashy drongo, jungle babbler [47] and white browed bulbul [48] are selected for counting their visits in comparable farms across five agroecological zones of Andhra Pradesh.

2.2. Experimental Design and Statistical Analysis

The experimental design used in this study is a "**nested design**" [49], where two treatments are executed in five locations, namely natural farming and chemical farming on comparable farms. For each of these treatments, the major source of variance is the bird population in natural and chemical farms (Factor 1). The second factor of bird population is in natural and chemical farms at time intervals (Factor 2). The variance in different time intervals in different agroecological zones is another source of variation (Interaction effect between time and agroecological zones). The bird population in agricultural systems (natural and chemical farming) is nested in five agroecological zones and four-time periods at different levels in this nested design. While analysing different elements at different levels, the nested design strategy offers equal advantages [50]. We hypothesize that different farming practises may impact differences in bird population and that there may be regional and temporal differences. The sources of variance are explained in the following table (**Table 2**). Our statistical analysis is divided into three steps. To examine the main effects of Factor 1 on fifty comparable farms, we have first performed an independent t-test on all five agroecological zones. The main source of variance for Factor 2: the variation in bird population visiting natural farms versus chemical farms at different time intervals (main effects of Factor 2). Another source of variation is the interaction effect of bird population in Time*Agroecological zones. For the statistical analysis, we used MANOVA.

Third, it is to study the common bird species visiting natural and chemical farms in five agroecological zones where the data was recorded on a Likert scale.

Table 2. Source of variance at each stage of the study.

Source of variation	Levels of analysis
Main effect of Factor 1	Bird population in natural and chemical farms
Main effect of Factor 2	Bird population in natural versus chemical farms in different agroecological zones and time intervals
Interaction effect (Factor 1*Factor 2)	Bird population in natural farming versus chemical farming in various time intervals*agroecological zones

This data is analyzed using nonparametric independent test. Before performing these tests, we evaluated the data for normality using **Shapiro-Wilk's test**, and the *p*-values obtained from these tests were not significant (more than 0.05), indicating that the data fulfilled the normality condition. The pre-requisite requirements for MANOVA are that the **Box's M (*p*-value is 0.466)** has a non-significant value greater than 0.05. This validates that the covariance matrices are assumed to be equal and that the test parameters are fulfilled. Similarly, the results of **Lavane's equality test** in MANOVA are non-significant. To determine the frequency of diverse bird species on comparable farms in different agroecological zones, the normalcy criteria for Likert scale data were not satisfied. Because the calculated z-scores from skewness and kurtosis for the data on bird species in different agroecological zones are not in the range (−1.96 to +1.96), and the *p*-values from Shapiro-wilk's test for most of the bird species are statistically significant (*p*-value 0.05), the data does not meet the requirement for normality. Therefore, we used a non-parametric independent Sample median test. To test the reliability of the questionnaire data on bird species we used the *Cronbach*'*s Alpha test*, and the **Cronbach's score is 0.937**, which implies the data collected is reliable [51].

3. Results

3.1. Bird Population in Natural Farms versus Chemical Farms

Our initial phase of investigation consisted of analysing the average bird population in fifty farm pairs (n = 100) from two different treatments in all agroecological zones. We used an independent t-test, in which the source of variation is the number of birds on fifty comparable natural versus chemical farms in five agroecological zones. The results of t-test show that there is a statistically significant difference between the number of birds visiting natural farming fields and chemical fields across all agroecological zones at the 5% level of significance (*p*-value < 0.001). In similar vein, there is significant difference in the bird visits in north coastal, Godavari, Delta zone, Southern zone and scarce rainfall zone as shown the following graph (**Figure 1**). The north coast zone has a higher bird population in natural farms when compared to other agroecological zones in natural farming fields. In all agroecological zones, farms that adopted natural farming methods receive more bird visits than other agroecological zones selected for the study.

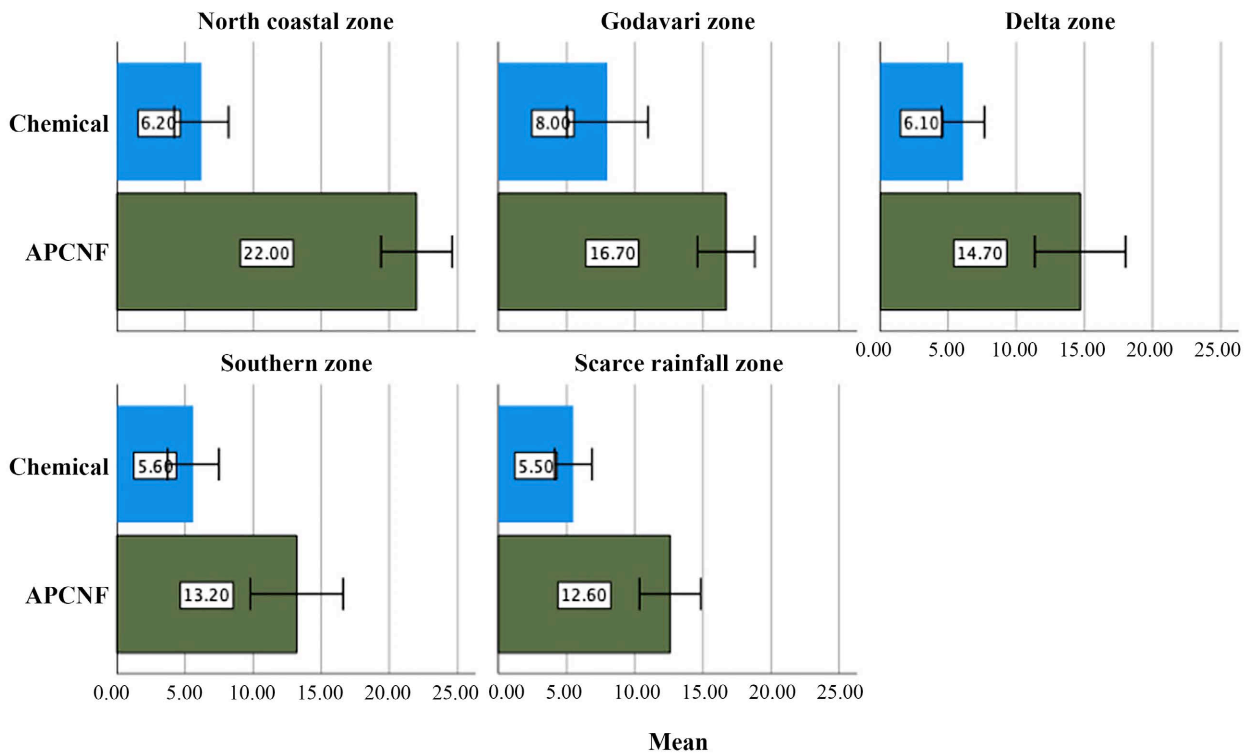


Figure 1. Mean bird population in natural versus chemical farms in all agroecological zones.

When comparing APCNF fields to chemical farms, the Godavari zone has the second-highest average bird population. Bird visits are steadily decreasing, beginning in the Godavari zone and proceeding to the zone of scarce rainfall. Changing climate, farming patterns, and pesticide usage might all be factors. The results show a significant variation in bird count in comparable farms, which can be attributed to the fact that the shift toward agroecological approaches such as natural farming, which does not use synthetic agrochemicals, encourages birds to return to natural farming fields to a greater extent.

The test between-subject effects summarise the main effects of Factor 1 (bird population in different farming systems, natural and chemical), the interaction effect of bird population in natural farms versus chemical farms in different agroecological zones, the Error, and the total variance of the dependent variables (bird population in natural versus chemical farms) in the nested design being studied are shown in Table 3. The variance associated with different levels is shown by the sum of squares for natural and chemical farms.

Table 3 reveals that there is a statistically significant difference in bird visits to natural farming fields in the five agroecological zones (p-value < 0.001), but no statistically significant difference in bird visits to chemical fields in the five agroecological zones (p-value > 0.05). Therefore, there is a significant difference in natural farming fields and chemical fields across all agroecological zones at different time intervals (p-value < 0.001) between the 50 natural farms and chemical farms analysed.

Table 3. Tests of between-subject effects.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	APCNF	574.52[a]	4	143.63	9.392	<0.001
	Chemical	40.68[b]	4	10.170	1.259	0.300
Intercept	APCNF	12,545.28	1	12,545.28	820.31	<0.001
	Chemical	1971.92	1	1971.92	244.18	<0.001
Agroecological zone	APCNF	574.52	4	143.63	9.392	<0.001
	Chemical	40.68	4	10.170	1.259	0.300
Error	APCNF	688.20	45	15.29		
	Chemical	363.40	45	8.07		
Total	APCNF	13,808.00	50			
	Chemical	2376.00	50			
Corrected Total	APCNF	1262.72	49			
	Chemical	404.08	49			

[a]R squared = 0.455 (Adjusted R squared = 0.407), [b]R squared = 0.101 (Adjusted R squared =0.021), at 5% significance level.

3.2. Bird Population in Different Time Intervals and Agroecological Zones

The descriptive statistics for the bird population at various time intervals (Table 4) reveal that the mean bird population values in natural farms at various time intervals between 6:00 am and 6:00 pm are significantly greater than in chemical farms at the same time period. Similarly, the coefficients of variation are lower for natural farms, indicating a higher degree of prediction, but the coefficients of variation are larger for chemical farms, indicating a greater level of dispersion around the mean. Across all time intervals, the bird population at 6:00 am in both natural and chemical farms reveals that birds make significant morning visits.

The pairwise comparison results of MANOVA in natural farms at various time intervals between different agroecological zones show a significant difference in the number of birds within group at 6:00 am between the north coastal zone and the southern zone, and a significant difference between the north coastal zone and the scarce rainfall zone (p-value 0.028). Likewise, the number of birds around 6:00 am differs significantly between the Godavari and the Delta zones, between the Godavari and southern zones, and, between the Godavari and the zone with scarce rainfall. In similar vein, there is a difference between agroecological zones in chemical farms at 6:00 am, between the north coastal and southern zones where the significant value is 0.006 and the scarce rainfall zone (p-value is 0.01). In addition, there are statistically significant differences between the north coastal and southern zones and the scarce rainfall zone at a significance level of 5%. Also, there is a significant difference in bird visits between the Godavari zone and the southern zone, and between the Godavari zone and the scarce rainfall zone at 6:00 pm.

Table 4. Descriptive statistics of mean and standard deviation.

Bird count at different timings	N	Mean	Std. Error	Std. Deviation	Coefficient of variation (%)	Sig.
APCNF at 6:00 am	50	16.06	0.45	3.20	19.92	0.005*
CHEM at 6:00 am	50	10.84	0.32	2.29	21.12	0.013*
APCNF at 8:00 am	50	13.94	0.33	2.34	16.78	0.177
CHEM at 8:00 am	50	9.32	0.27	1.93	20.70	0.692
APCNF at 4:00 pm	50	13.58	0.29	2.10	15.46	0.312
CHEM at 4:00 pm	50	8.62	0.28	2.00	23.20	0.087
APCNF at 6:00 pm	50	9.06	0.31	2.24	24.72	0.326
CHEM at 6:00 pm	50	5.02	0.26	1.86	37.05	0.359

APCNF: natural farming fields; CHEM: Chemical farming fields, * significance based on test between subject effects in agroecological zones.

Overall, the results indicate that there are significant differences between the geographical and temporal scales in the birds visiting natural and chemical farms. The results of multivariate analysis as presented in **Table 4** show that there is a significant difference in bird count at the temporal scale in different agroecological zones. The results show that the number of birds in different agroecological zones varies and is strongly influenced depending on time interval.

The MANOVA results to examine the results on main effects of bird count in different time interval and the interaction effect of Time*Agroecological zones reveal that there is a significant difference in bird count between natural farms versus chemical farms in four different time intervals. The test statistics for time and interaction effect of Time*Agroecological zones are significant as indicated in **Table 5**.

3.3. Abundance Bird Species in Natural Farms

Non-parametric median analysis of independent sample was used because the Likert scale data did not meet normality requirements. We assume that the medians of each bird species are the same across agroecological zones regardless of the farming practice. Nevertheless, the results of the independent median sample test show that the medians of each bird species differ significantly ($p < 0.001$) in all agroecological zones, disproving our hypothesis (**Table 6**).

The results of Kruskal-Wallis Test for testing the difference in median bird frequency between natural farming and chemical farming in different agroecological zones of Andhra Pradesh (**Table 7**) showed that there is a statistically significant difference in bird frequency between natural farming and chemical farming in the agroecological zones in the state. The Kruskal Wallis H and Chi-Square values for each bird are listed in **Table 7**. The median values for all the birds studied are statistically significant between natural agricultural fields and chemical fields across all agroecological zones in Andhra Pradesh. The Kruskal-Walli H values, Chi-square values and the significant levels for each bird species are indicated below.

The following figure taken in Kurnool district during the survey, in a scarce rainfall zone, shows that in natural farming fields (**Figure 2**) the birds feel safe laying eggs in the field itself. The photo shows the eggs of the baya weaver bird in natural farming field. Generally, the Baya weaver bird builds its nest under thorny trees or near water, but this is an interesting observation that these birds build their nests in natural farming fields.

Table 5. Test results of MANOVA[a].

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.97	178.72	7.00	39.00	<0.001
	Wilks' Lamda	0.03	178.72	7.00	39.00	<0.001
	Hostelling's Trace	32.07	178.72	7.00	39.00	<0.001
	Roy's Large Root	32.07	178.72	7.00	39.00	<0.001
Time*Agroecological zone	Pillai's Trace	0.95	1.88	28.00	168.00	0.008
	Wilks' Lamda	0.28	2.12	28.00	142.03	0.002
	Hostelling's Trace	1.77	2.37	28.00	150.00	<0.001
	Roy's Large Root	1.30	7.79	7.00	42.00	<0.001

[a]Design: Intercept + Agroecological zone, within subjects design Time. N = 100.

Table 6. Results of Independent-Sample Median Test: Rejects the null hypothesis.

S. No.	Null Hypothesis: medians of bird species are the same across the agroecological zones	Test	Sig.[a,b]
1	The medians of common mynah	Independent-Samples Median Test	<0.001
2	The medians of rose ringed Parakeet	Independent-Samples Median Test	<0.001
3	The medians of erget	Independent-Samples Median Test	<0.001
4	The medians of sparrows	Independent-Samples Median Test	<0.001
5	The medians of crows	Independent-Samples Median Test	<0.001
6	The medians of Indian rollers	Independent-Samples Median Test	<0.001
7	The medians of quail birds	Independent-Samples Median Test	<0.001
8	The medians of baya weaver birds	Independent-Samples Median Test	<0.001
9	The medians of red vented bulbul	Independent-Samples Median Test	<0.001
10	The medians of ashy drongo	Independent-Samples Median Test	<0.001
11	The medians of jungle babbler	Independent-Samples Median Test	<0.001
12	The medians of white-browed bulbul	Independent-Samples Median Test	<0.001

[a]Significance level is 0.05, Asymptotic significance (It is based on assumption that the data set is large, significance at 0.05 level).

Table 7. Results of non-parametric sample median test.

Bird species	Grand Median	Kruskal-Wallis H	Chi-Square	df	Asymp.Sig.
Common mynah	2	46.09	37.79	9	<0.001
Rose ringed Parakeet	2	67.14	60.87	9	<0.001
Egret	2	57.69	44.42	9	<0.001
Sparrows	2	78.29	78.65	9	<0.001
Crows	2	59.32	47.85	9	<0.001
Indian rollers	2	58.71	40.00	9	<0.001
Quail birds	2	56.22	38.84	9	<0.001
Baya weaver birds	2	59.43	35.97	9	<0.001
Red vented bulbul	2 2	49.91	39.24	9	<0.001
Ashy drongo	2	62.63	45.13	9	<0.001
Jungle babbler	2	67.66	57.24	9	<0.001
White browed bulbul	2	68.30	58.58	9	<0.001

Asymp.Sig: The significance level is generally 0.05 and is shown when the data set is large.

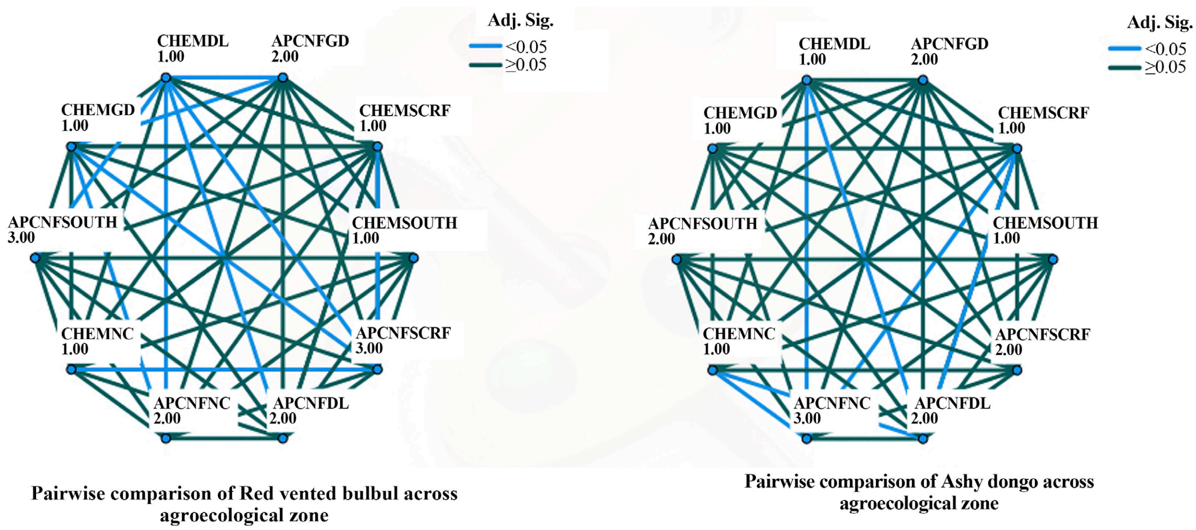
Figure 2. Nest of baya weaver bird in natural farming field, Phot Courtesy: Natural Farming Fellow, Kurnool.

The pair-wise comparative charts for specific species such as Baya weaver birds and red vented bulbul (Figure 3) the natural farming bird frequency versus chemical farming fields in various agroecological zones of Andhra Pradesh are shown below. The graphs generate different nodes with specified ranks for natural farming adopted fields and chemical farms in different agroecological zones.

According to the data in Figure 3, all natural farming nodes have a significantly higher average rank than chemical nodes. For example, the data obtained for red vented bulbul shows that the average rank of APCNFNC (natural farming fields in the North-coastal zone) is two and the average rank of CHEMNC (Chemical farms in the North-coastal zone) is one. The ashy drongo data for all agroecological zones are statistically significant at the significance level of $p < 0.005$. Accordingly, the average node rank of ashy drongo for APCNFDL (Natural farming adopted farms in Delta zone) is 2.5, while the average node rank for CHEMDL (Chemical farms in Delta zone) is one. Apparently, the blue lines in the graphs represent significance level for all the nodes for red vented bulbul is <0.05. The significance lines connect different nodes with average rank node that is significant at significance level of 0.05. Each node in the graph shows a sample average rank of agroecological zone.

Similarly, the diagram shown in Figure 4 shows that the bird sparrows have been dominant in the natural farming fields between the north coastal, Godavari zone and the Delta zone. But, in case of southern zone, Jungle babblers are more seen around the natural farming fields. While the Baya weaver bird abundance is seen in the natural farms of scarce rainfall zone. In contrast, the graph shows that there is a significantly very low abundance of bird species in the paired chemical farms compared to natural farming fields in all agroecological zones. The bird species erget is apparently, dominant in chemical farms of north coastal zone and there is not much variation in bird species in chemical farms of Godavari zone. The crows are dominant in chemical farms of Delta zone and southern zones.

The distribution of sparrows in natural and chemical farms (Figure 5) reveals that the species is more abundant in APCNF fields located in the north coastal, Godavari, and Delta zones. Whereas chemical farms are ranked low to extremely low in all five zones. In general, species visits are higher in natural farming fields than in chemical farming fields across all the agroecological zones. We have observed similar pattern of bird species for all the bird species studied.



APCNFNC: Natural farms in Northcoastal zone
CHEMNC: Chemical farms in North Coastal zone
APCNFGD: Natural farms in Godavrai zone
CHEMGD: Chemical farms in Godavari zone
APCNFDL: Natural farms in Delta zone
CHEMDL: Chemical farms in Delta zone
APCNFSOUTH: Natural farms in southern zone
CHEMSOUTH: Chemical farms in southern zone
APCNFSCRF: Natural farms in scarce rainfall zone
CHEMSCRF: Chemical farms in scarce rainfall zone

Figure 3. Pairwise comparison graphs of red vented bulbul and ashy drongo.

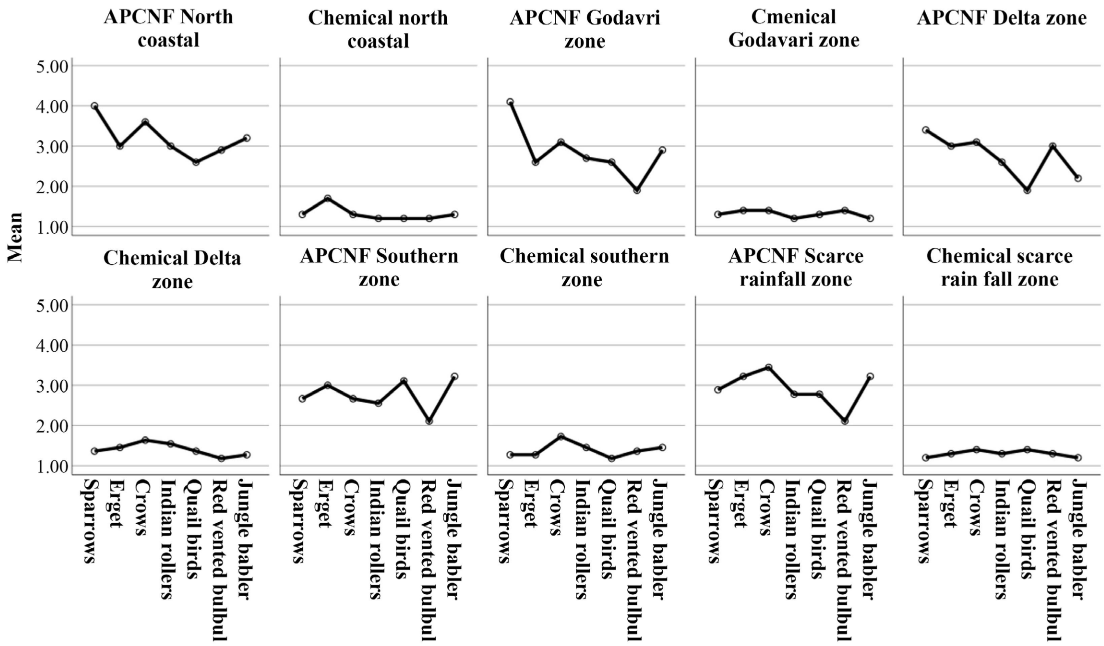


Figure 4. Species wise bird abundance in different agroecological zones in natural vs. chemical farms.

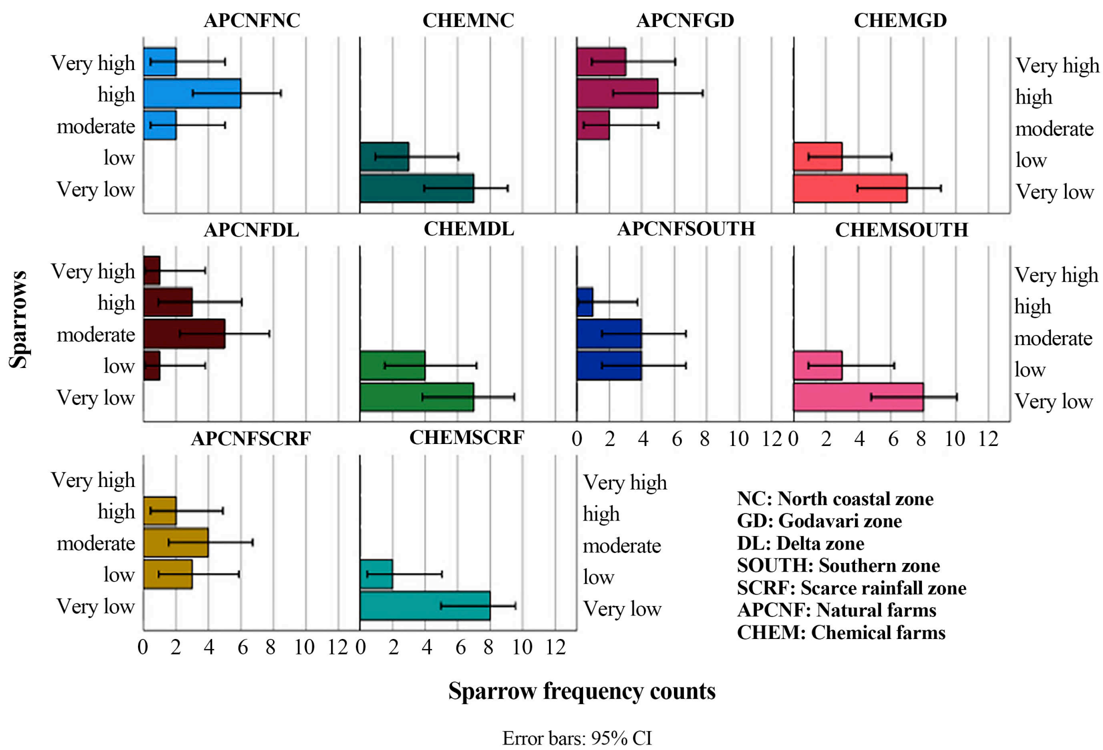


Figure 5. The distribution of sparrows across agroecological zone in natural versus chemical fields.

4. Discussion and Conclusions

In this study, we sought to test the hypothesis that there might be variations in birds visiting natural farming and chemical farming fields in different agroecological zones and at different times of day. The findings support the study's many theoretical assumptions and demonstrate that natural farming, as an agroecological approach, has higher bird visits in natural farming fields than chemical farms. The experimental design in which the treatments: bird populations in natural vs. chemical farms in various agroecological zones are nested together in ecological systems. This study established the main effects of the sources of variation in relation to variations in bird population between natural farms and chemical farms. The main effects of changes in bird population between agroecological zones, as well as the interactions between agroecological zones and time intervals, have also been identified. According to the various studies the results reveal that there is a substantial difference in bird visits between farms that use alternate farming techniques and those that use chemical farming methods. These findings complemented the findings of earlier studies [52]. These differences could be attributed to differences in farming intensity, chemical usage in that zone, and landscape biodiversity, among other factors [53]. Paddy, chillies, and cotton are the key crops in India that consume a large amount of pesticides. Cotton uses about 40% of pesticides, paddy consumes approximately 25 percent of pesticides, and chilies consume approximately 24% of pesticides [54]. The average number of bird visits is greater in the north coastal zone than in other agroecological zones, which may be related to the existence of a dense forest cover that offers better habitat for birds as confirmed in the literature [55]. The findings imply that natural farming's fundamental principles, such as increasing crop diversity, enable avian species to feel more secure, which increases the number of birds that return to natural farms [56]. The scarce rainfall zone has fewer birds since it contains a greater number of barren areas devoid of trees; various studies demonstrate that where there are more barren lands, there are fewer bird visits [57]. There are a variety of reasons for the decline in bird populations in diverse agroecological zones. For example, in the scarce rainfall zone, farmers grew only groundnuts in one season, and rainfall is low due to the low tree density. The major portion of this region has a semi-arid environment, and tree density has decreased dramatically in the recent decade, from 10.8 percent to merely 2.03 percent [58] the fields are kept sparse and lack vegetation for longer periods in a year. The approach of keeping land cover year-round in natural farming fields provides food for the birds in terms of grains, worms as well, these practices attract the bird species [59]. In contrast, the intensification and intense use of chemical in Godavari and Delta zones can repel the birds rather than spending a long period of time. The data show that sparrows, ashy drongos, baya weaver birds, and red vented bulbuls are more common in natural farming fields than in chemical farming areas.

The differences in bird visits during different intervals in this study confirm the results that support this variation in bird behavior counting at different times of the day as the birds follow their clocks and visit as needed [60]. Natural farming methods such as Jeevamrutham and mulching increase the microclimate with lower temperature compared to outside temperature which attracts a wide variety of bird species where birds lay eggs and stay for longer periods in natural farming fields [61]. Similarly, practices such as placing bird perches in natural farms provide a better resting space for birds to sit down and prey on certain insects; these practices encourage an increase in bird population in natural farming fields. Typically, chemical farming techniques do not include these practices in their package. The study has provided a speck of evidence that the adoption of natural farming practises in agricultural landscapes contributes to the revival of bird populations to their natural habitats. The reasons for variances in bird counts throughout Andhra Pradesh's distinct agroecological zones require further inquiry, and the frequency of various species visiting natural farms is a potential path for future research.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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