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Spatiotemporal Contribution of Participants in Patrolling Efforts from a Forest Station, Pu Hu Nature Reserve, Vietnam

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Abstract: Understanding the contributions of participants from management practices and those from the local community to protected areas (PAs) as nature reserves, is crucial for forest protection and resource conservation. Thus, empirical studies have usually investigated whether patrolling has significantly improved forest protection action. Many previous studies have exhaustively examined the contributions to forest protection by rangers or local persons, but there has been little research on the contribution of both sides to patrol efforts with separate consideration given to each. This paper explores insights into the patrol efforts in the Nam Tien forest station. The total number of patrollers, walking distances, and working days across years were significantly different between the ranger and local person patrol groups. There was a considerable variation in the number of patrollers ($Z = 2.02$; $p < 0.01$), distance ($Z = 2.45$; $p < 0.01$) and working days ($Z = 2.37$; $p < 0.01$) between rangers and local persons related to monthly patrolling. For the traditional patrols in the various PAs, it is shown that, for long-term forest protection, local persons patrolling should be considered more, in order to achieve the sustainable conservation.

Keywords: conservation; forest protection; patrol; rangers; local persons

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1. Introduction

Protected areas (PAs) like nature reserves (NRs) are increasingly becoming final shelter locations for threatened species and natural ecosystem processes [1] and the main method of managing resource conservation [2]. NRs are the cornerstones of endeavours for safe conservation, and help minimise the destruction of natural resources [3] of Pas. Furthermore, and concurrently, the assignment of conservation areas as NRs has significantly increased their responsibilities from just managing conservation to also supporting human needs [4]. As local and global attempts to protect conservation areas extend, the socio-economic impact of nature reserves on surrounding communities continues to be debated strongly [5]. With their iconic landscapes and resources, these areas are now looked to for attaining and increasing diverse socio-economic requirements along with conservation objectives [6]. In reality, the various NRs are essentially vulnerable to human requirements and encroachment and other environmental stresses [7]. The relationship between NRs and poverty is the subject of long-running discussions in academic and policy circles [8].

With the continuing exploitation of forests, reports are frequently made on the negative impacts of this on the local people [2]. There is no doubt that biodiversity loss and forest depletion in PAs continues to increase because of society's demands [9,10]. Biodiversity conservation and poverty reduction have both become international, societal, and political goals [11]. However, many agencies and government authorities only consider the biodiversity in PAs when the PA is the home of rare and endangered species.

As a result, the success of protected area management in most NRs in developing countries, like Vietnam, relies on the support and cooperation of the local communities [10]. Even so, conflict between the authorities and local people is increasingly common because of society's demands [9,11]. To impose conservation legislation consistently, the NRs must be kept separate from the local inhabitants and cultivated areas [11]. To reduce any conflict by patrollers that may arise, law enforcement is necessary for conservation activities in NRs. Forest stations enrol local persons from the fringe villages as local patrollers [12]. As human populations grow in mountainous areas, the conversion of PAs for purposed land uses is considered as a result of political and social pressure [13].

In a number of research projects on protecting forests, it is commonly accepted that management planning for PAs should consider activities for the local people around the specific PAs [14]. Direct attention has been given to discerning how this forest management planning may lead to conservation [15]. Community-based forest management programs have often failed to realise their stated objectives of participant-based conservation [16]. However, Pu Hu NR has received results from long-term cooperation between the local community and the relevant authority, i.e., the rangers [17,18]. Many studies in recent years have investigated the positive results of patrolling efforts for the future of conservation, but there has been little insight offered to law enforcement. Significantly, the local people have been regularly contributing to forest protection for a long time. In previous research, community-based conservation management has been found to have been particularly successful [19] when illegal activities could be anticipated along specific tracks because of the patrollers' intelligence about such matters.

Maintaining the effectiveness of patrolling by local persons is an important problem faced by managers of all protected areas in Vietnam, such as Nam Tien FS, Pu Hu NR [18]. The rangers' patrol monitoring system is a significant management tool for surveillance and forest protection, and a major way in which conservation is achieved [20]. Patrol performance is measured based on patrolling days, hours, distance, speeds, and relative altitude, and these factors reflect the difficulties rangers face when working in the field. Furthermore, physical threat [21,22] and insufficient or improper equipment for regulating law enforcement efforts [21] may also have an impact on the effectiveness of local persons.

Nam Tien FS under Pu Hu NR has been monitoring the patrolling tracks using GPS data logging devices and it is currently one of the most well-known protected areas in Thanh Hoa Province and indeed, throughout the whole of Vietnam. Rangers' efforts and the current illegal findings and takedowns through regular patrol-based monitoring are reported in the rangers' monthly meetings. In addition to the ranger-based monitoring system, the management board has also committed to rotating rangers between forest stations to reduce any bias in patrol reports over long-term patrolling.

The main objective of this paper is to ascertain whether there are different contributions from rangers and local persons on each patrolling track in forest stations. This will be done in accordance with achieving the following dual objectives: to consider patroller performance and to gain insight into the patrolling effort of rangers and local persons over the time given. This study is to support the significant evidence of protectors in PAs who constantly contribute to the conservation activities over the long-term.

Background of Policy

Our data is based on those from forest stations that were participating in the Vietnamese government's policies 120/2015/QD-TTg and No.38/2016/QD-TTg in 2015 and 2016 that were about forest protection and development, investment for supporting in-

frastructure, and assignation of public utility tasks to agricultural and forestry companies. Money was made available for protectors in protected areas who contributed to protecting forests directly. In addition to this, based on No. 120/2005/QD-TTg, there were around 300,000 VND/ha (1.3 USD/ha) available. However, the payment for forest protection was dependent on law enforcement efforts related to the work fields and contribution made by each local person. Furthermore, forest officers calculated a fixed budget for protection activities and took responsibility for the distribution of working fields for each patroller.

A management board has always established local forest guard groups in the first year and monitored the work fields at the end of the year. Depending on the law enforcement performance of each patroller, the head of the forest station points out the negative and positive patrolling activities and suggests the list of patrollers to manage the board. The amount of finance available is announced in the meeting based on patrolling day records.

2. Materials and Methods

2.1. Area of Interest

Nam Tien forest station (FS) belongs to Pu Hu NR, which is spread over two districts (Quan Hoa and Muong Lat) in Thanh Hoa province with protection of around 24,000 ha. Pu Hu NR lies in a rugged location (latitude 20°30′ and 20°40′ N, and longitude 104°40′ and 105°05′ E) [23] in the northeast of Vietnam (Figure 1). It was established as a special-use forest area in the year 1999 by the government of Vietnam and is governed by Pu Hu Management Board. Since the establishment of the NR, and under the control of the surrounding forest stations such as Nam Tien FS, all exploitation of forest resources has been forbidden. The extraction of forest resources and other related economic activities by local people in the surrounding areas were monitored by the FS [24].

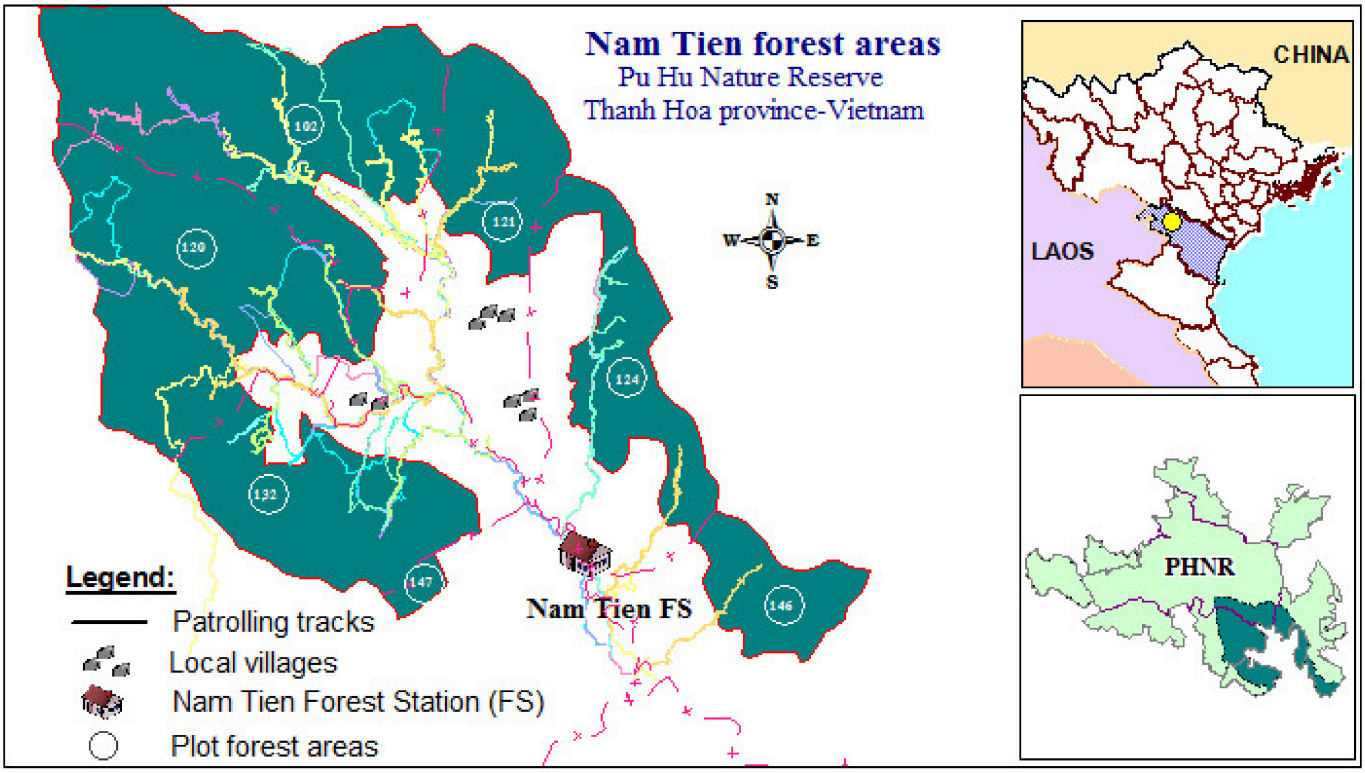


Figure 1. Location of case study area in Pu Hu NR.

At present, conservation protection activities are under high pressure due to people's requirements. Nam Tien FS is one of several forest stations around Pu Hu NR. The allocated forest rangers have been implementing law enforcement measures frequently, even though this openly reveals conflicts [25,26] between themselves and the local people. Nam Tien FS

takes responsibility for protecting this area of almost 5000 ha by dividing it into various sub-area forest plots. The permanent rangers and LFGs are in charge of the practical patrol efforts of the whole forest area. In the buffer zone, there are around 423 households and 1512 inhabitants in 12 villages of Nam Tien and Thien Phu communities [19]. Their participation in community-based conservation was seriously considered because of their knowledge and skill in the working fields. Members of local authorities at different levels always consent to conservation activities and to the suggestions of members of the local person patrols.

2.2. Data Sources

Based on conventional law enforcement measures and use of foot patrols, the greatest number of analyses of patrol efforts were observed by the central offices of Pu Hu NR [17]. This study collected data from April 2019 to June 2021 in the central office, specifically of Nam Tien FS. All the patrol routes taken by patrollers and represented in Figure 1 using GPS collected data, relate to the monitoring application system. Furthermore, the patrol tracks are displayed in both Google Earth and MapInfo software for analyzing the monthly reports [17] and data sheets or patrol staff logbooks [25,27], with significant information gained. The man-days patrolled from one day were calculated in 8 h [10] as in the following equation:

$$Patrolling - days = \sum_{i=0}^{n} \frac{i}{8} \quad (1)$$

where i indicates the reality of patrolling time.

2.3. Statistical Analysis

The number of patrol kilometers walked, team days spent, and the relative altitude covered [26] based on measurements from the GPS device, were estimated using the Google Earth software application. All the accepted data were transferred into Microsoft Excel to come up with the activity report. And SPSS version 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) was used to describe the statistics, analyze the data, and determine any significant differences ($p < 0.05$) among the variables. The various variables were represented in terms of mean $\pm$ SD (standard deviation) [28] with normally distributed data; therefore, non-parametric statistics were used in the analysis with the Spearman rank (rs) correlation being used to derive correlation coefficients and Man-Whitney (U) (two variables) tests used to compare means for significant differences. Furthermore, Wilcoxon tests were used to compare two related variables for significant differences. In particular, a linear regression framework was used to examine the relationships among the related variables [13].

2.4. Preparation and Management in Patrols

The application of conventional law enforcement using foot patrols is implemented when patrollers like rangers and local persons' survey and record tracks and waypoints using GPS devices. After a short discussion among the rangers in the Nam Tien station, the head of the station makes a decision on who is in charge of the next-day patrol and where it will be.

Importantly, local persons could be selected and be informed of the relevant information on the patrol tracks such as the name of a location, who is accompanying them, staff's preparation, and starting-time [10,27,29]. Normally, the target location in forest plots is distant from Nam Tien, taking 10 to 45 min by motorcycle, when starting-patrols on foot [25]. The leading team takes responsibility for the start and end points of the patrol during the patrol time [30]. Such patrols are often undertaken in response to intelligence information [31] on the most illegal activity encountered, if it is possible.

After each patrol, information is recorded and these are tabulated into a summary consisting of Excel worksheets which are submitted to the director of the Pu Hu NR and discussed in monthly meetings. However, in some cases, the information from the patrol

rangers has been directly provided as feedback to management to enable them to solve issues on time [29,32] (Figure 2).

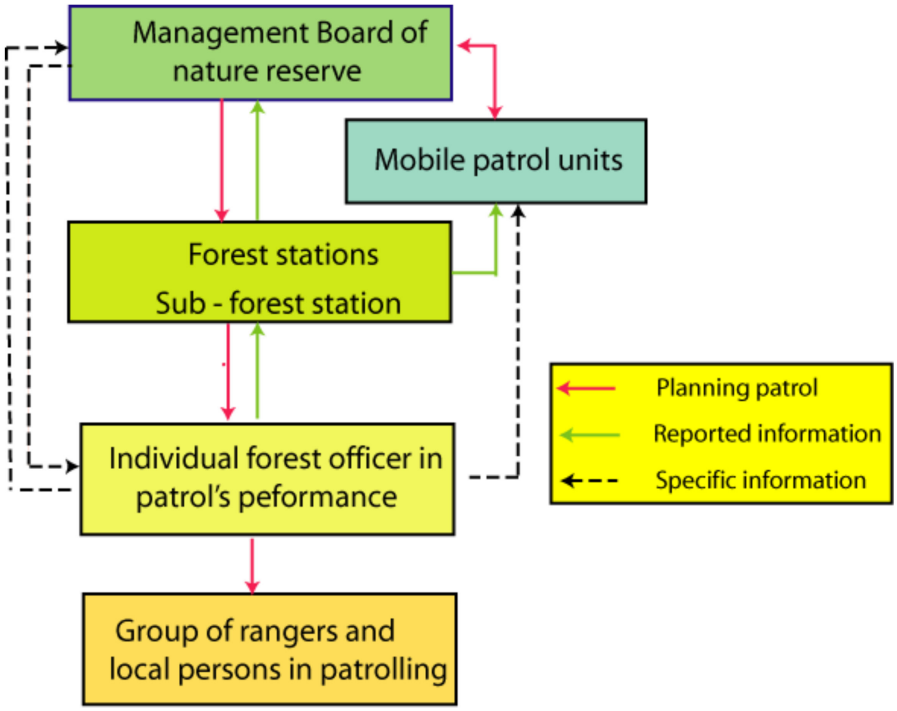


Figure 2. The framework of working system in NRs. Updated [33].

3. Results

All the patrol routes (Figure 1) were established where illegal activity occurs easily. The basic information for each sub-area forest plot consists of the different sizes, distances, and relative altitudes of protected areas (Table 1).

Table 1. Summary of sub-forest plots in Nam Tien protected areas.

Sub-Areas	Name of Communities	Size of Sub-Areas Ha	Distance from Forest Station Km	Relative Altitude m
102	Nam Tien	1240	9–10	1200–1320
120	Nam Tien	1081	7–9	926–1125
121	Nam Tien	754	8–9	850–930
124	Nam Tien	574	8–9	541–635
132	Nam Tien	658	6–7	230–335
142	Nam Tien	100	2–4	353–430
146	Nam Tien	678	7–8	454–540
147B	Nam Tien	36	3–4	600–752
142	Thien Phu	545	7–8	720–822

Updated [25].

3.1. Yearly Patroller's Performance

The number of monthly patrolling days by both types of patrollers in 2021 was significantly reduced (38.83 patrolling days/month), compared to the previous two years (around 55 patrolling days/month). In particular, the number of working days in the field by rangers was slightly lower, while the monthly local days in 2020 reached 30.2 patrolling days/month (Figure 3). However, the distribution of average patrolling day by local persons (SD 1.45 $\pm$ 0.50) was higher than the rangers' patrolling (SD 1.38 $\pm$ 0.49). The average number of working days, (including forest rangers and local persons), were

monthly operating days for patrolling over three years (2019, 2020, and 2021) as follows: 3.11 (SD = 0.68), 2.98 (SD = 0.45), and 2.18 (SD = 0.38) respectively.

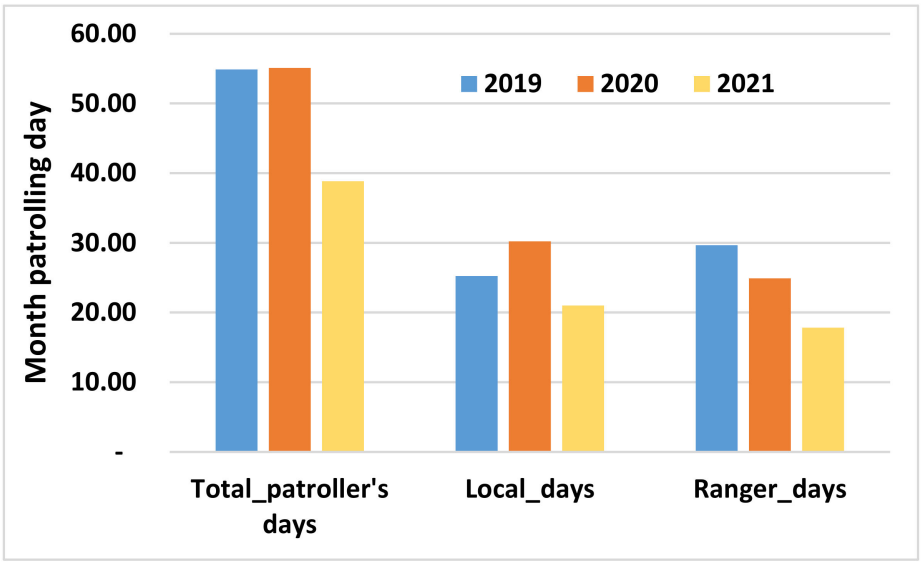


Figure 3. The trend of average distribution of working in the field by patrollers during the time.

There was a decline in the average distances in 2019 (19.94 ± 8.09) and 2021 (11.08 ± 5.37) and working day (8 h/day) in 2019 (1.23 ± 0.93) and 2021 (0.84 ± 0.55). Additionally, there was a considerable decline in patrolling distances/months 2019, 2020, and 2021 (316.85 km, 288.11 km, and 197.56 km respectively). In patrolling hours/month, there was a similar increase in 2019 and 2020 with around 20 patrolling days. The lowest was about 14 patrolling days in 2021 (Figure 4).

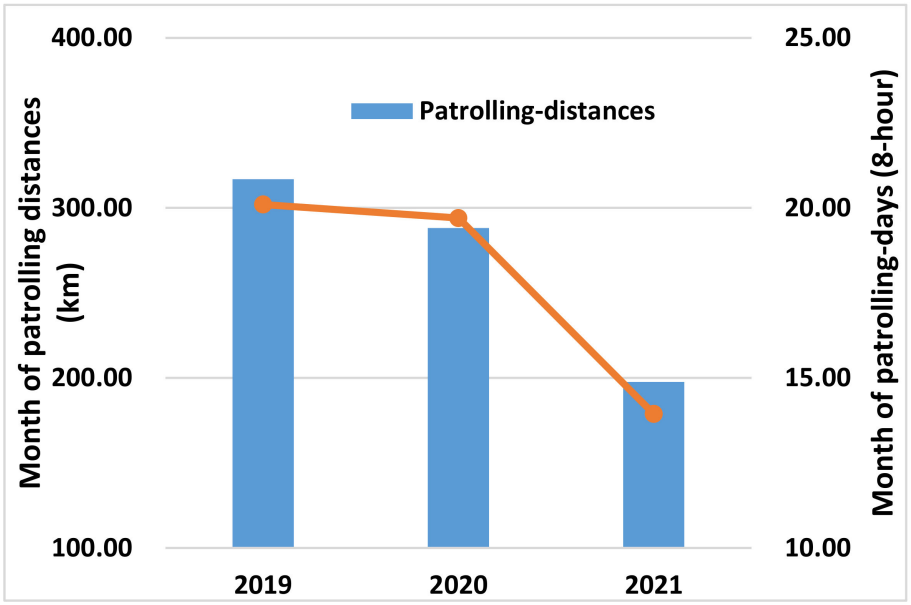


Figure 4. The trend of average patrol-distance and –days by both patrollers.

Furthermore, the number of patrollers in each month in 2019, 2020, and 2021 was positively correlated with the number of distances (rs = 0.76, rs = 0.55, and rs = 0.46, $p < 0.01$ respectively) and working days (rs = 0.60, rs = 0.51, and rs = 0.36; $p < 0.01$, respectively). Similarly, the patrolling distances were positively correlated with the working

days (rs = 0.96, $p < 0.01$). By contrast, the relative altitudes and speeds in patrolling had no correlation with others.

3.2. Considered Patrollers' Performances

3.2.1. Patrolling Enforcement Efforts

The average number of rangers, distances, and working days were 1.38 ± 0.49, 7.44 ± 4.03, and 0.50 ± 0.35. The number of patrolling rangers was significantly correlated with the walking distance (rs = 0.74, $p < 0.01$), working days (rs = 0.69, $p < 0.01$), and patrolling speeds (rs = 0.69, $p < 0.05$) during those months. Particularly, there was a significant difference in the number of rangers, walking distances, and working days (H = 71.68, $p < 0.01$; H = 25.78, $p < 0.01$, and H = 33.79, $p < 0.01$, respectively) (Figures 5 and 6).

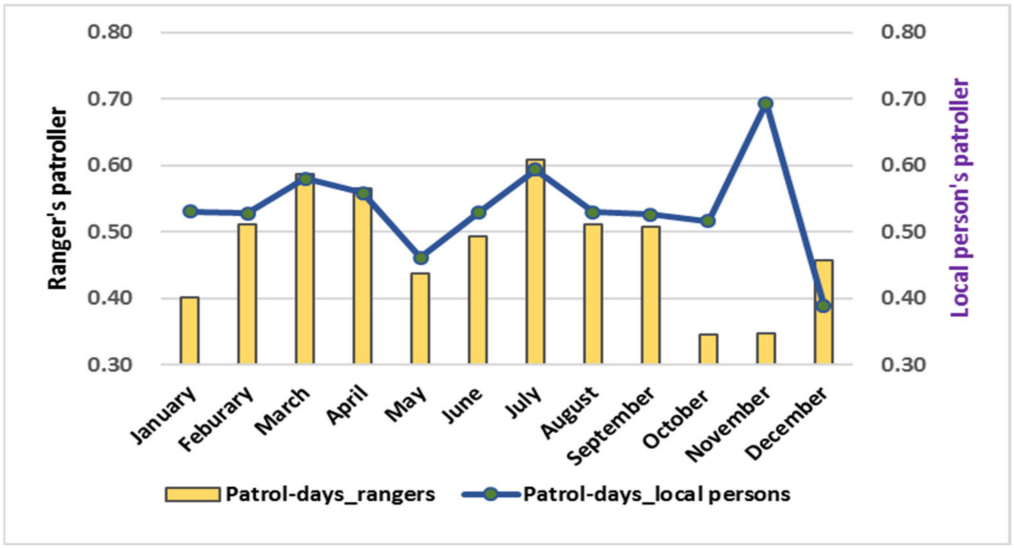


Figure 5. The average patrol-day during the time.

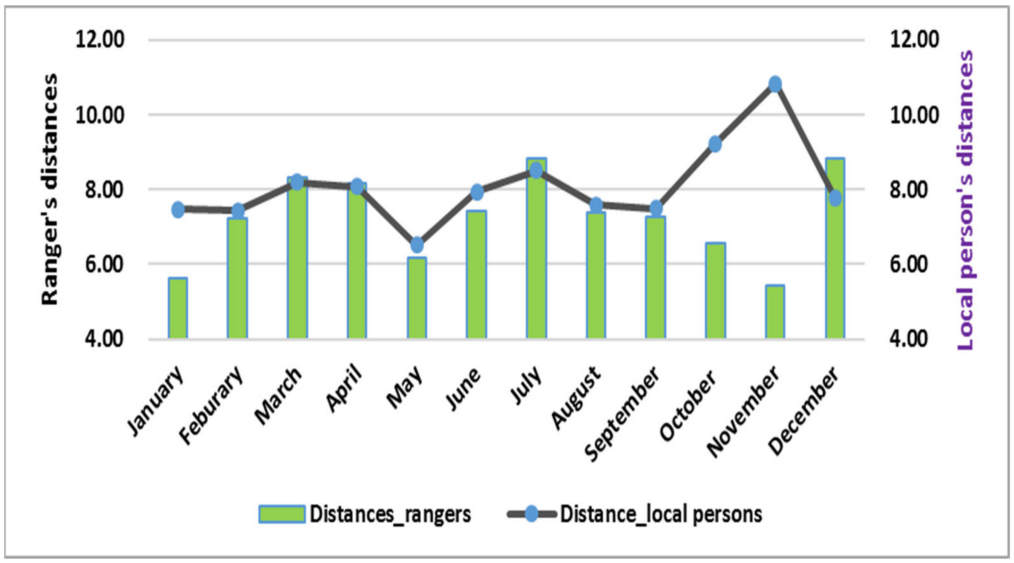


Figure 6. The average patrolling distances during the time.

Thanks to local patrollers, the average local persons, distances, and working days were 1.45 ± 0.50, 8.00 ± 4.46, and 0.53 ± 0.37. The number of local persons was moderately correlated with walking distances and working days (rs = 0.73, $p < 0.01$; rs = 0.71, $p < 0.01$). The numbers of local persons and walking distances were significantly different

during monthly patrolling (H = 89.17, $p < 0.01$; H = 33.79, $p < 0.01$). Furthermore, the number of local persons was fluctuant and there was a peak of kilometers walked and patrol days in November (around 11 km distances/per month and 0.7 h-day/per month) (Figures 5 and 6).

3.2.2. Duplex Patroller Efforts

Regarding total patrollers, the average totals of the patrollers, distances, and working days were 2.83 ± 0.65 persons, 7.44 ± 4.03 km, and 0.50 ± 0.35 8-h/per day. The number of patrolling patrollers was significantly correlated with the walking distance (rs = 0.43, $p < 0.01$), working days (rs = 0.30, $p < 0.01$), and patrolling speeds (rs = 0.11, $p < 0.05$). Opposite to this, there was no correlation between the number of local patrollers and patrolling speeds, as found in [19].

In particular, there was a significant difference in the number of total patrollers and patrolling speeds (H = 61.93, $p < 0.01$ and H = 38.23, $p < 0.01$, respectively), while there were no differences in the distances (H = 15.47, $p < 0.01$) and working days (H = 10.19, $p < 0.01$) in the patrolling performances measured.

4. Discussion

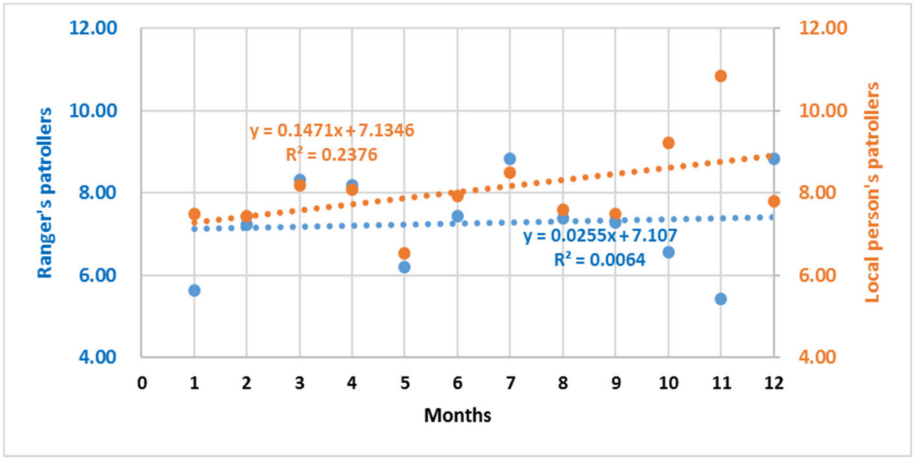
Generally, the patrolling days by rangers decreased because a number of rangers were transferred other offices or other duties by the head of Pu Hu Management board and local authority [19]. When there was a decline in the number of rangers, the head of the forest station needed more local persons to participate [17]; thus, the total number of patrollers, rangers and local persons, was stable during this 3 year research. More importantly, it could be supposed that there would be better patrol performance, since as the number of patrollers increases, they should be able to spend more time on patrolling as well as travel further distances [29,34]. However, patrol movement was usually irregular because of adaptation of lessons learned, urgent information, and current occurrences [21]. This is evidenced in the first year when the number of illegal activities inside an NR are ordinarily smaller, compared to the last of year.

Additionally, there was considerable decline in working days and distances by rangers that were the lowest at 2.7 patrolling days and 6.0 km/per month distances in October and November (Figures 5 and 6). Actually, it is the rainy season in this month; therefore, it is very difficult to patrol because of slippery walking [10,29]. In these instances, the number of patrolling rangers is limited because they are not used to patrolling in the field compared to the local persons [19]. Thus, the head of the Nam Tien Fs organizes the local persons in villages to carry out patrolling in the field with a steady number of patrollers [11]. In addition to this, it seems to be that the accounts of illegal encounters like logging, transportation, and hunting exponentially decline in lessons learned [23,27], thus the number of rangers beforehand, was excessive.

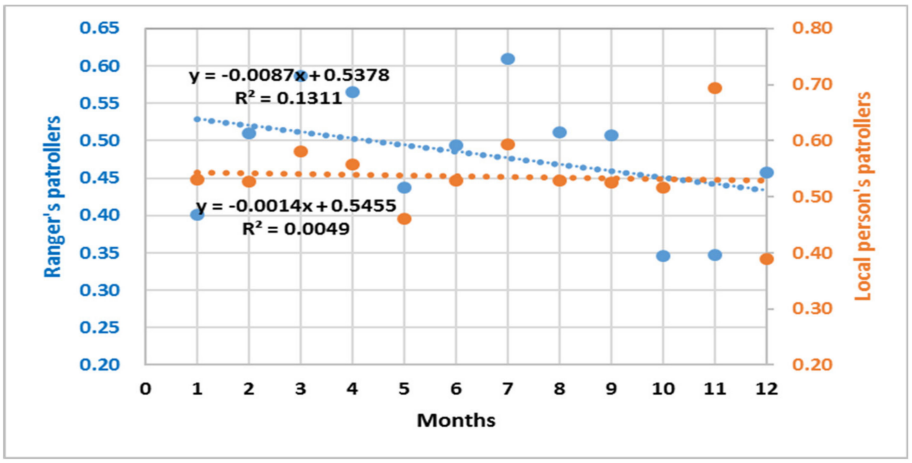
The total number of rangers in Pu Hu NR is regularly fixed and recruited by the government. They are also transferred to other protected areas or authority offices by the government. Depending on the various situations of each of the forest stations such as Nam Tien, the number of rangers was changed by the Pu Hu management board. Particularly, the number of permanent rangers in Nam Tien FS was three persons in 20120, while the numbers were steady at two rangers, in other years. Thus, the effects of working days and walked distances increased when the number of patrollers was increased in the station because the forest station was able to exchange patrollers, as is the case in various PAs in Ghana [32], northern Gonarezhou National Park and adjacent areas in Zimbabwe [29], as well as Pu Hu nature reserve in Vietnam [23].

Similar to [29,32] in Ghana, and [23] in Vietnam, the monthly walking distances per year have altered significantly through the years. Furthermore, the trend in the monthly distances walked by rangers was stable, while there was a significant increase in local persons' patrolling performance. Furthermore, the working days by rangers were considerably in decline but steady for local persons (Figure 7). There are similar to the results

of [34] and [10]. However, another researcher found that there was no significant difference in the distances across the years [11]. The main benefits of the work for the rangers were monthly salaries and the incremental salary increases over 3 years if the rangers had no breaches of discipline [23]. Furthermore, the extra logistics provided patrolling field were consistently intensively low. Thus, it took the consequence of the low motivation of patrolling activities [29,34]. There were no significant differences in relative altitudes and speeds when the patrol road was stable which is similar to the findings of [17]'s study in Vietnam because patrollers are used to the available tracks [22].



(**a**)



(**b**)

Figure 7. The trend of patrolling activities over the years ((**a**) walked distances; (**b**) working day).

5. Conclusions

This study indicates the importance of local persons in law enforcement patrolling in Nam Tien FS. The key indicators patrolling efforts, patrol days, and walked distance, are the most important indicators for identifying which local persons could be significantly better at patrolling than the rangers. The patrol monitoring system represented in this research has furnished useful feedback to evaluate the management of Nam Tien forest areas [25]. Indubitably, forest management at local level makes for easier conservation when local people are interested in forest activities like reducing deforestation pressures [35].

Furthermore, tropical forest managers and local persons may find out how the participant in law enforcement efforts should be [14]. The huge number of studies on the subject of local participants in projects in developing countries has supported various authors to synthesize the primary factors underlying the success of local people's participation in local projects [29]. As in the research for the case study, the number of patrollers significantly

correlated with walked distances and working days. Furthermore, local persons' efforts in PAs have been contributing more than local rangers in specific aspects of performance, even though they are not powerful, according to government policy. The various aspects of participation in forest protection management by local persons and rangers should be invested in and evaluated. Education, age, finance, and knowledge could be influential factors for patrollers to consider when contemplating working in the field.

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