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Review

Terrestrial Protected Areas and Food Security: A Systematic Review of Research Approaches

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Abstract: Achieving food security is one of the most important sustainable development goals and is a major global concern, specifically in remote and rural areas of the developing world where high biodiversity can be found and many protected areas are located. The goals of food security and biodiversity conservation are two of the most critical challenges of our time. This study aims to better understand the state of research on protected areas and food security through a methodological lens. The literature search was conducted in the Web of Science core collection and the Centre for Agriculture and Biosciences International (CAB) abstracts database. The search results indicate that this is an understudied topic with only nineteen articles published in various research domains. The findings reveal that studies were explanatory research rather than confirmatory and most studies had a snapshot design with no control or baseline. National parks were the main category of protected areas reported in studies. Data collection commonly employed a combination of qualitative and quantitative methods at a household level. We also found that spatial data and methods are important yet underutilized.

Keywords: food security; biodiversity; protected areas; conservation; systematic review

1. Introduction

Food security and nutrition is a key humanitarian challenge around the world. The latest global estimates suggest that more than 820 million people—one in nine humans—are hungry, and this trend is on the rise in almost every continent [1]. World population growth, climate changes, economic recession, and conflict instability are some of the major drivers of food insecurity that are affecting the global food system [1]. Equally alarming is over a million species currently at risk of extinction as reported by the Intergovernmental Panel on Biodiversity and Ecosystem Services. Changes in land and sea use, the exploitation of natural resources, climate changes, pollution, and invasive alien species are the major drivers of change in natural resources that have led to biodiversity loss [2]. Hence, the goals of food security and biodiversity conservation are two of the most critical challenges of our time [3–5] and there is an urgent need to find a balance between human needs and conservation goals.

Studies show that there are overlaps between biodiversity hotspots and areas suffering from poverty as most conservation hotspots are located in countries with a high prevalence of poverty [6] and food insecurity [4,7]. Historically, researchers addressed these issues separately, but recently it has been acknowledged that both topics can be well connected [5,8–10]. The establishment of protected areas (PAs) is considered one of the most important methods of environmental conservation and protection

against degradation [11–14]. Conservation initiatives can impact poor rural and food insecure people that are heavily dependent on ecosystem services and natural resources to meet their needs, including food [6]. Indeed, poverty and food insecurity go hand in hand in the world [15] and there is a bi-directional relationship between poverty and environment that creates a poverty–environment nexus, a vicious cycle where environmental degradation negatively impacts the local livelihood, which leads to depletion of more natural resources and this cycle continues [6,16].

This study aims to better understand the state of research on PAs and food security through a methodological lens by reviewing the research designs and methods of this specific line of research. The relationships between PAs and food security are complicated and the methods used to study these relationships will influence the understanding of the topic. The results of studies conducted on the impacts of PAs on food security are varied and sometimes contradictory. We hypothesized that the differences in methods used in these studies might be a possible explanation for the heterogeneity of these results. We reviewed published peer-reviewed studies conducted on the impacts of PAs on human food security and nutrition. Specific attributes, including the year and primary discipline of study, country, name of the protected area, IUCN category, data collection level, study design and data collection, and analysis methods, were extracted from selected articles for analysis. To our knowledge, there is no study conducted on the review of methods applied to assess the impacts of PAs on food security, and this analysis is intended to address this research gap.

The Intersection between Food Security and Protected Areas

Following World War I, food security emerged as a global issue in international policies. The first food security measurement was conducted by the newly established Food and Agriculture Organization of the United Nations (FAO) in 1946 to address the question: are there enough calories for everyone in the world? The results showed that around one-third of the world population at that time could not get enough calories [17]. Later in 1996, at the World Food Summit, food security got its globally accepted definition as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [18]. Based on this definition, food security is a multifaceted subject. However, studies show that much of the research on food security has been conducted in an agricultural science discipline with the primary focus on methods to increase the production of calories [3,19]. Although securing the required calories has critical importance, utilization and stability are also important but perhaps less focused aspects of food security [19].

Protected areas (PAs) as the primary method for conservation [11–14] have various objectives from strict nature conservation to the areas with limited permission for sustainable development. However, conservation is the primary objective of all categories of PAs [11]. PAs are mostly less agriculturally developed areas where poor and marginalized people reside and historically, they were the less advantaged part of society [20–22]. Conservation is a relatively new concept that is defined by the Western notion of nature as untouched land that is separated from human and it fails to acknowledge the intertwined relationship between people and nature in the rest of the world [10]. Indeed, conservationists in the nineteenth century established PAs to conserve biodiversity without serious considerations about their impact on human wellbeing for those that are living inside or around the PAs. Specifically, in regions such as Africa, conservation plans were generally based on the Western values and notion of nature and local people; their needs and livelihood were excluded [23].

The concept of the negative impact of PAs on humans gained attention after the Rio Summit in 1992 and became recognized officially in the Convention on Biological Diversity in 1993. Later at the World Parks Congress in 2003, activists reached the agreement that PAs should not harm the local people [13]. Literature suggests that PA's impact on humans is both positive and negative [13], but evaluating this impact is challenging for several reasons [21]. First, the contribution of natural resources to household wellbeing varies substantially in different areas. Second, the studies are mostly on the prediction of the social impacts of PAs or measuring the current impacts of PAs without any baseline or consideration

about the situation before the establishment of PAs. Third, studies over time or longitudinal studies are required to monitor the changes in household's welfare affected by PAs [21]. A comprehensive review of the impacts of conservation on human wellbeing in the developing world [24] reveals that the majority of studies were on the economic impacts of PAs, while less than two percent of studies were conducted on the human health outcomes of PAs. In particular, studies on the outcome of conservation on nutrition were surprisingly scarce [24].

Fostering ecosystem services for farmers in the region, introducing new livelihood options like tourism, and improving infrastructures, are examples of positive impacts of PAs on human wellbeing [13,25]. For many centuries, humans have used wild food to stay alive and this is still the case in many areas of the world [10,26]. Wild foods work as a "safety net" during the crisis and help people to improve their resilience [20,27,28]. For instance, studies on park-adjacent communities in the Republic of Congo and Zimbabwe revealed that bushmeat has an important role in the ability of people to obtain food. Besides direct consumption, some households earned cash from hunting as well [29,30]. A global study on the economic contribution of wild foods to rural livelihood reveals that 77 percent of households harvest wild food, which represents an important source of income generation and food security for many [31]. Wild food is especially important for people that are living far from the cities and markets and their associated benefits. Studies show that generally, the poorest and most food-insecure households use wild food as the coping strategy to increase their resiliency [30,32,33]. In general, in the literature of parks and people, there are some comprehensive studies in which the authors argue that PAs will improve human wellbeing by a providing better livelihood situation [34]. This might explain why the population growth on the edge of PAs in Africa and Latin America was almost two times higher than the average rural growth [35].

On the other hand, if inappropriately implemented, PAs can cause physical and economical displacement, social conflicts, and increased vulnerability to poverty [25,36]. In regions where people's livelihoods are dependent on natural resources with limited alternative options, the impact of conservation, especially restricted access to natural resources in PAs, can lead to negative impacts on human health [37]. For instance, removing access to wildlife in Madagascar increased the number of children with anemia by 29% [38]. Moreover, conflicts with wildlife, crop riding and damage by animals, and competition with wildlife over natural resources are other examples of the negative impacts of PAs on human food security [39–41]. For example, a study conducted in the Kakum conservation area in Ghana showed that the livelihood of people living in that region was negatively affected by PA through three pathways. First, unemployment increased due to the restrictions over activities inside the PA. Although ecotourism has the potential for employment, because of the high rate of illiteracy and lack of skills required for working in this sector, very few local people could be employed in the ecotourism sector. Second, because of the ban on hunting the number of wildlife and consequently the frequency of farm raids and crop loss by wild animals increased. Finally, restriction over the use of natural resources (either for direct consumption or selling at the market) made many small-scale seasonal farmers economically inactive during the off-farm season [37]. PAs can also negatively impact local people's coping strategies for climate change-related events. For example, a study conducted on the impacts of Limpopo National Park on local people in Mozambique showed that because of the restriction posed by the park, people could not apply their traditional coping strategies during hardships like drought periods. Activities such as hunting and charcoal production were not available anymore for people, and consequently, people had more difficulty to meet their basic needs such as food [40]

While the overlap between food security and conservation is recognized, studies show that PAs that consider local people as stakeholders are more successful in meeting both goals of conservation and improving people's livelihoods [10,42]. A recent study of more than thirty developing countries showed that living near PAs could improve household wealth and reduce the risk of poverty. In addition, children living close to PAs had better food security conditions [34]. There is also a growing body of literature about the positive association between forest covers and diet diversity in the developing

world [43–46]. However, it is important to acknowledge that since PAs have different governance structures, the results from forests may not apply to the protected forests.

PAs produce either positive or negative impacts on human rights to food. Hence, from a broader ethical and moral perspective, decisions made regarding conservation and PAs cannot be solely based on ecosystem values, and the human rights component of food security should be considered in people and parks studies. Some researchers consider PAs an example of a telecoupled situation where the global drivers of land use change, override the local drivers of change [47]. In this situation, the cost of global public goods such as biodiversity conservation cannot be a conservation program without local communities needs and rights considerations: that is conservation at the expense of local poor people [36,48]. Alternatively, applying rights-based approaches to conservation, with acknowledgment of the inalienable human rights to food, can be a promising pathway towards just and resilient conservation [10].

2. Methods

A literature search was carried out in July 2019 and then updated in June 2020 in: (a) the Web of Science Core Collection (Clarivate Analytics) as the oldest multidisciplinary search engine, covering more than 21,000 peer-reviewed, high-quality journals, and (b) Centre for Agriculture and Biosciences International (CAB) abstracts database as a leading bibliographic database in applied life science literature. The search was conducted on articles in English without any limitation on publication time. That means the Web of Science (WOS) search period was 1900–2020 and in CAB abstracts the coverage backs to 1973. Terminologies for PAs in the search string were partially adapted from a review study of human wellbeing impacts from protected areas [13]. To capture as many relevant studies as possible, we also added more possible terminologies for PAs in our search string. Search terms were selected broadly to cover all possible terminologies used to describe both protected areas and food security and we used an asterisk to capture as many relevant variations of words as possible, starting with our search string's words. The search string had two parts. The first part was about different terminologies for "protected areas" (n = 15), the second part after "AND" was about different terminologies for food security (n = 4). We used the Boolean operator "OR" to separate different search terms within each part and "AND" to separate two sections. The search string was as follows:

(protected area * OR nature reserve * OR wilderness area * OR "national park *" OR natural monument * OR natural feature * OR management area * OR world heritage site * OR biosphere reserve * OR biodiversity conservation OR conservation reserve * OR conserved area * OR wildlife management area * OR landscape protected area OR community conserved area *) AND (food security OR food OR nutrition * OR human)

Articles found by the search string were stored in the RefWorks library. In this study we applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach [49] to screen the articles and identify the appropriate articles for the review. Relevance screening of articles followed sequential steps. A total of one thousand and ninety-seven articles were found by the search string in English in the WOS Core Collection and CAB abstracts database. The first step of relevance screening was conducted on all titles to exclude irrelevant and duplicate studies. After excluding seven hundred and ninety-two articles, three hundred and five articles were selected as the result of title screening. The second level of relevance screening on abstracts and some full texts excluded two hundred eighty-six articles, resulting in the final set of nineteen eligible papers. Data regarding the methods used to measure the impacts of PAs on food security were extracted from these nineteen articles. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram for this study is illustrated in Figure 1.

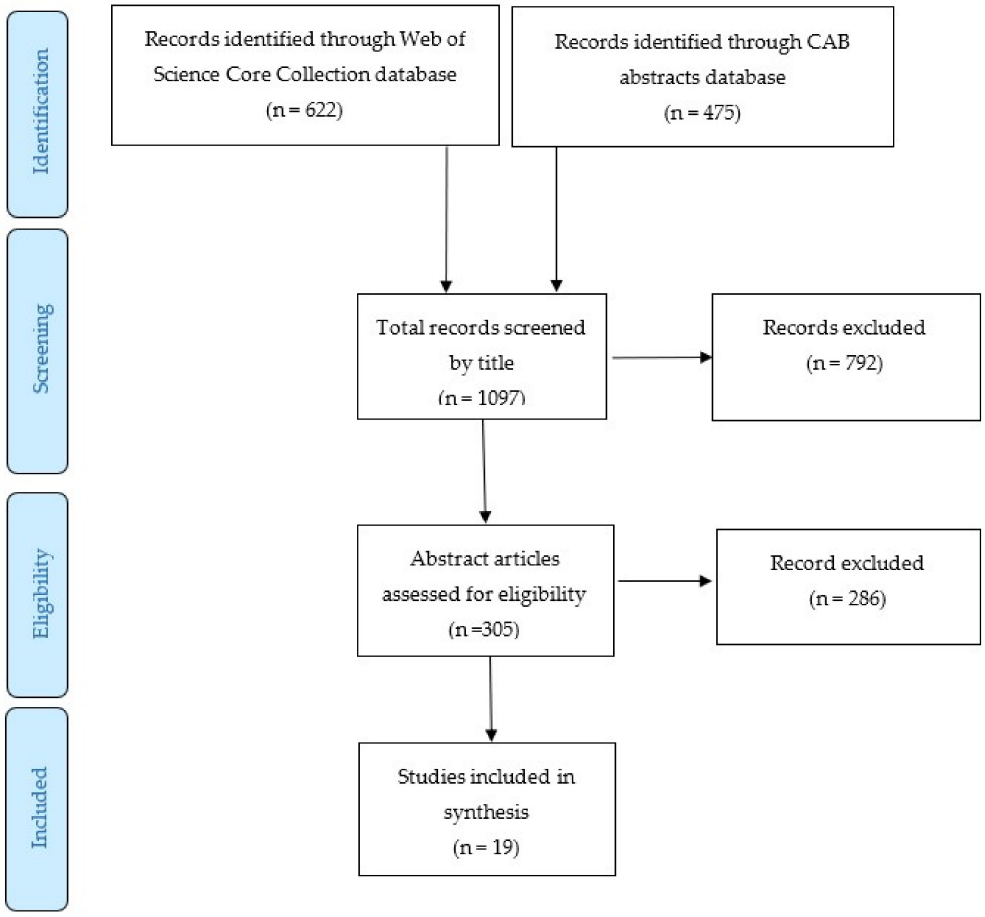

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram [49].

The inclusion criterion for this review was empirical studies (not reviews) conducted on nutrition and food of people living within or around PAs. Ethnobotanical studies that discussed the traditional knowledge of people about plants and studies exclusively on economic outcomes of PAs were excluded from this review. After finding the appropriate articles, we reviewed them across seven categories. Table 1 shows the reviewed categories, the definition for each category, and the coding items used in this study. We reviewed the nineteen included studies to extract the data regarding country and regions, primary research domains of study, IUCN category of the PAs, names of the PAs, data collection level, methods of data collection, and methods of data analysis. We used descriptive statistics to report the quantitative trends in the literature.

Table 1. The selected review categories for the papers with their definition and coding.

Review Category	Definition	Coding
Country/Region	The country/region that study took place	Name of country
Primary research domain	The primary research domain of the journal according to Web of Science categories	The primary research discipline
IUCN category	Six management categories based on IUCN category of PA	Ia: Strict nature reserve Ib: Wilderness area II: National park III: Natural monument or feature IV: Habitat/Species management area V: Protected landscape/seascape VI: Protected area with sustainable use of natural resources Unknown/not applicable
Name of protected area	The name of PAs that study took place	Name of PAs as it is mentioned in the study
Data collection levels	The impacts of PAs on food security was measured at this level	1. Individual 2. Household 3. Other
Methods of data collection	Methods for collecting data about food security	1. Observation 2. Anthropometric measures 3. Interview surveys: Structured/semi structured/open ended questions 4. 24-h Dietary Recall 5. Survey Instrument6. weighed food-consumption survey 7. Other
Methods of data analysis	Methods used for analyzing the data	1. Correlational [e.g., regression] 2. Perception 3. Researcher inference 4. Mean, max, min 5. Other

3. Results

3.1. Overview of the Publications Retrieved

Our results indicate that from 1974 until 1990, all publications on food and PAs were exclusively about wildlife food chains and animals' food habits whereas human needs were not mentioned. Considering the fact that the primary goal of PAs is conservation [11], it is not a surprise that the predominant research theme on human-PA interactions is the impacts of humans on the PAs, not vice versa. The first studies in the late 1970s were concerned about the impacts of humans on PAs and wildlife in the U.S. [50,51]. Almost two decades later, the first study on the impact of PAs on humans emerged [52]. Entitled 'conservation at human cost: Case of Rajaji National Park', this study examined the negative impacts of Rajaji national park on local livelihoods in India. This work was published in *Economic and Political Weekly*, which suggests that this topic (impacts of PA on humans) initiated from an economic discipline, and not an environmental, conservation, or ecology discipline.

The study on "food consumption pattern by native Canadians" living in a boreal forest [53] was the first article discussing human food consumption and PAs. This study showed that one-third of the total meat consumption by the native community, regardless of their access to the market, was from wild meat. The study concluded that wild food has an important role in the food basket of native Canadians. No other published studies were found until early 2000, when a new trend of publications emerged on conservation, food production, and crop biodiversity at a global scale. Almost ten years later (late 2000s), the number of publications on PAs, ecosystem services, and livelihood showed some

increase. However, based on our searches, from 1991 through 2006, for almost fifteen years we could not find any empirical studies on the impacts of PAs on food and nutrition of humans.

Regarding the primary research domains of reviewed studies, the results indicate that the majority of studies on this topic were published in environmental science and ecology (n = 5), followed by biodiversity and conservation (n = 4), food science and technology (n = 3), science and technology-other topic (n = 2), public environmental and occupational health, agriculture and forestry, area studies, development studies, and human dimensions of wildlife, each disciple with one article. To determine the associated discipline, we used the primary research domain of the journals reported in the WOS. Only two journals were not indexed in the WOS and we used their title (development studies and human dimensions of wildlife) as their primary research domain. Figure 2 illustrates the distribution of articles based on the publication year and their associated research disciplines.

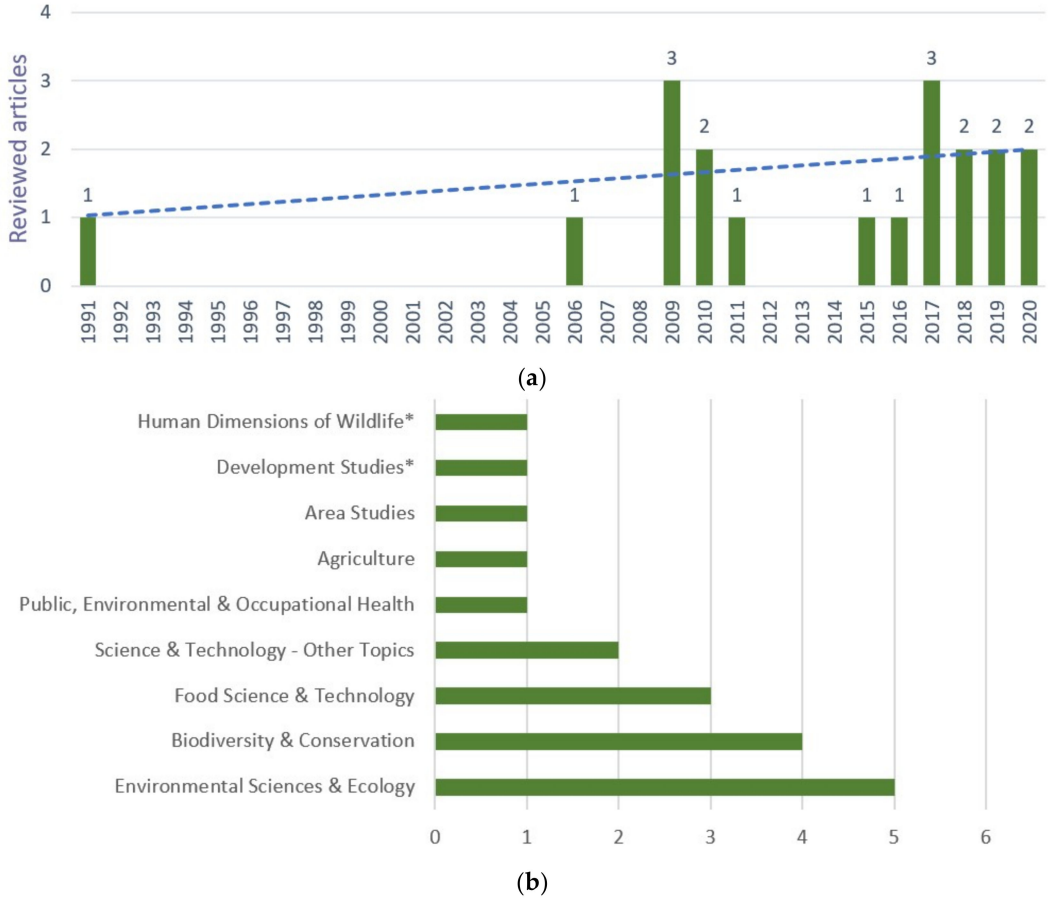

Figure 2. (**a**) The distribution of the number of reviewed articles by the year of publication and (**b**) primary research domains of reviewed studies.

3.2. Geographical Distribution, Conservation Status and Scale of Food Security Assessment

With respect to the study location, the results indicate that almost sixty percent of studies (n = 12) were conducted in Africa. The geographic distribution of studies by country is illustrated in Figure 3 and as follows: four out of nineteen studies took place in Gabon, three from Madagascar, and two studies were from Brazil. The rest of the studies were about Canada, India, Nepal, Bangladesh, Zimbabwe, Congo, Thailand, Uganda, Mozambique, and Rwanda, as one study per country. One study [34] was conducted on a global scale.

Figure 3. Location of study sites by country.

In connection with the geographic area covered in the study, our results show that more than eighty percent of studies (n = 16) took place in areas adjacent to protected areas. Regarding the IUCN category of PAs [54], sixty-three percent of studies (n = 12) took place in national parks (IUCN category II). Thirty-seven percent (n = 7) of the studies had "unknown/not applicable" IUCN categories. It is worth mentioning that the official status of protected areas cannot be used to describe how it is managed because where the customary land claims are common, law enforcement would be a challenge. Hence, activities like hunting and logging occur in some national parks despite the legal prohibitions [20].

Regarding the data collection level, our results indicate that the majority of the studies (84%, n = 16) measured food security at a household level, followed by eleven percent (n = 2) at an individual level, and one study at multi-level including community, household, and individual levels. The high-level analysis can mask the heterogeneity at the lower level. For example, a study [48] conducted on wild meat consumption in Makira Natural Park of Madagascar at community, household, and individual levels found remarkable variation regarding wild meat consumption among communities as well as among households. According to their findings, poor and more food insecure households rely more on wild meat to feed the family, as poorer households' wild meat consumption is reported to be three times more than wealthier households. However, at an individual level within the household, they did not find variation regarding meat consumption while the distribution of caloric food such as rice or stew was based on individual body mass.

3.3. Methods Used in the Publications

As far as data collection and analysis methods are concerned, our review reveals that some combination of qualitative and quantitative methods, such as interview, focus group, weight food consumption, 24-h dietary recall, and anthropometric measurements (body size), is most common. The main methods for quantitative data analysis were correlation and regression analysis.

Regarding the research approaches, through reading the nineteen articles included in this review, three general observations emerged. First, studies were explanatory research rather than confirmatory. That means studies were conducted on either (a) investigation of the contribution of wild food to the health and wellbeing of affected communities within or around the PAs or (b) exploring the impacts of PAs on food security of affected populations. Considering the fact that the topic is understudied, it is understandable there are not solid theories required for conducting confirmatory research. The second observation was that most studies had a one-time snapshot design with no control or baseline. Very few studies considered the control group or before/after the establishment of PAs in their study designs. We did not observe any change regarding the approaches in impact evaluation over time.

In addition, this review shows that despite the importance of spatial understanding of this topic and the availability of data, these datasets and methods were under-utilized. Using the map to show the study site was the most common application of spatial methods in the studies (n = 15, 78%). However, spatial methods go beyond simple mapping to show the study site. According to our results,

only two studies applied spatial data in their analysis. The first study was conducted across the developing world to investigate the impacts of PAs on human wellbeing [34]. This study utilized the Demographic and Health Survey (DHS) data. DHS is a publicly available geolocated dataset that covers detailed demographic, socioeconomic, and health data at individual and household levels. For PAs, they used "World Database on Protected Areas". The second study that applied spatial data was about provisioning ecosystem services on the edge of a PA in Zimbabwe [30]. In this study, data regarding the consumption of natural resources from PAs were collected at household level and the GPS location of households was used to quantify the distance to the edge of the PA. Their results indicate that there is a strong association between consumption of provisioning ecosystem services (e.g., food) and the distance to the PAs [30]. Table 2 illustrates the summary of data extracted from nineteen articles included in this review. The bibliographic information of articles can be found in the Table S1, in Supplementary Materials.

Table 2. The summary of data extracted from nineteen studies included in this review.

Citation	Primary Research Domain	Country/ Region	IUCN Category	Name of Protected Area[s]	Data Collection Levels	Methods of Data Collection
Llopis et al., 2020	Food Science & Technology	Madagascar	II: National park	Masoala National Park and Makira Natural Park	Household	Focus group discussions
Neelakantan et al., 2020	Environmental Sciences & Ecology	India	II: National park	Kanha National Park	Household	Survey + Interview + 7-day dietary recall
Borgerson et al., 2019	Food Science & Technology	Madagascar	II: National park	The Masoala National Park	Household	Descriptive statistics
Naidoo et al., 2019	Science & Technology-Other Topics	Developing countries	Unknown/not applicable	Various	Household	Secondary data, Anthropometric measures
Munanura et al., 2018	Biodiversity & Conservation	Rwanda	II: National park	The Volcanoes National Park	Household	Survey Instrument
Mavah et al., 2018	Biodiversity & Conservation	Congo	II: National park	The Odzala Kokoua national park	Household	Interview surveys: Structured/semi structured/open ended questions
Guerbois & Fritz, 2017	Environmental Sciences & Ecology	Zimbabwe	II: National park, and IV: Habitat/Species Management Area	Hwange National Park (IUCN Category II) and Sikumi Forest Area (IUCN Category IV)	Household	Interview surveys: structured/semi structured/open ended questions
Nakamura et al., 2017	Environmental Sciences & Ecology	Brazil	Fully protected area	Acaraí State Park	Household	24-h dietary recall and questionnaire about food security situation in last 3 months

Table 2. *Cont.*

Citation	Primary Research Domain	Country/ Region	IUCN Category	Name of Protected Area[s]	Data Collection Levels	Methods of Data Collection
Givá & Raitio, 2017	Area Studies	Mozambique	II: National park	Limpopo National Park	Household	Perception
Golden et al., 2016	Biodiversity & Conservation	Madagascar	II: National park	Makira Natural Park	At community, household, and individual levels	Survey and observation
Matsuura et al., 2015	Environmental Sciences & Ecology	Gabon	Unknown/not applicable	Moukalaba-Doudou National Park	Household	Semi-structured interview, weighed food
Foerster et al., 2011	Biodiversity & Conservation	Gabon	Unknown/not applicable	Monts de Cristal, Waka, Biringou and Ivindo	Household	Participatory assessment of resources, survey
Mukul et al., 2010	Science & Technology - Other Topics	Bangladesh	II: National park	The Satchari National Park	Household	Interview surveys: Structured/semi structured/open ended questions
Barirega et al., 2010	Human Dimensions of Wildlife	Uganda	II: National park	Queen Elizabeth National Park	Household	Questionnaire and focus group, dietary diversity indices
Adhikari et al., 2009	Agriculture	Nepal	Unknown/not applicable	Royal Chitwan National Park	Household	Interview surveys: Structured/semi structured/open ended questions
Blaney et al., 2009	Public, Environmental & Occupational Health	Gabon	Unknown/not applicable	The Gamba Complex of Protected Areas	Individual	weighed food, consumption survey, interview, and anthropometric measures
Blaney et al., 2009	Food Science & Technology	Gabon	Unknown/not applicable	The Gamba Complex of Protected Areas	Household	weighed food-consumption survey, observations, interviews, and anthropometric measures
Delang, 2006	Development studies	Thailand	Unknown/not applicable	Thung Yai Naresuan Wildlife Sanctuary	Household	Interview surveys: Structured/semi structured/open ended questions
Wein et al., 1991	Environmental Sciences & Ecology	Canada	II: National park	The Wood Buffalo national park	Individual	24-h Dietary Recall

4. Discussion and Research Implications

In spite of the importance of the topic, specifically in tropical areas and the developing world, there are very few published investigations on the relationship between PAs and food security.

This finding is supported by the results of a comprehensive review on the effect of conservation on human wellbeing [24] that revealed less than 2% of studies on human wellbeing were conducted on human health. It is also worth mentioning that food and nutrition is just one aspect of human health. Moreover, our review shows that almost all studies were conducted in the last decade. We found only one study [53] in the early 1990s. This suggests that the topic is understudied relative to its importance and the attention it has drawn from researchers is growing recently. In addition, except for one study in Canada [53], the rest of the studies were taking place in developing countries. This corroborates with a recent comprehensive study in which hunting wild animals was recognized as the main threat to the PAs in the developing world [55]. Among developing countries, almost twenty percent of studies (n = 4) took place in Gabon. These studies were the results of a five-year Park and People project funded by MacArthur Foundation, to scientifically evaluate the impact of PAs on human welfare [21,56–59].

Our literature review found that this topic has been studied in different disciplines. It can be explained by the fact that both food security and conservation are cross-disciplinary topics. Hence, to address food security and biodiversity conservation challenges, researchers from different disciplines need to step out of their discipline's boundaries and start to make progress in collaborative efforts. Not only has the topic been studied through different disciplines, but also the methods used in the studies varied widely. We found that different qualitative and quantitative methods such as interview, focus group, weight food consumption, 24-h dietary recall, and anthropometric measurements (body size) were applied to measure food security, and the measurements were mostly at household level. Food security measurements were conducted for different purposes through a multi-level analysis starting from the global to national, regional, local, household, and finally individual level [60]. The high-level analysis will mask the heterogeneity in the lower level. For example, the results of our review suggest that the majority of studies considered the household level their unit of measurement and analysis. However, since age and gender heterogeneity have existed in the household, the average impacts of PAs on households cannot capture the variance of impact on individuals [14].

Concerning the geographic area and spatial scale, it should be noted that conservation programs affect various stakeholders in different ways. Hence, reporting the average effect would not be enough, because it could mask the impacts on a specific part of the community [61]. Wealthy and powerful members of the community usually benefit the most from the PAs and vulnerable members of the community cannot get benefits like the others. Moreover, the impacts of PAs are intense on the local scale compared to the national scale [42]. Studies show that ecosystem benefits for humans such as food are varying across the scales and this spatial heterogeneity requires attention by policymakers [48]. This indicates a need for a better understanding of different aspects of human wellbeing in designing and governing protected areas [47]. Mapping the spatial and temporal heterogeneity of food security and conservation impacts on the community can be used as a strong management tool that provides the opportunity for decision-makers to be able to spatially identify areas with high priorities.

With respect to the research design, our result shows that most studies had snapshot design without control or baseline. This finding is supported by a systematic literature search on the approach used for evaluation of the social impacts of PAs, which revealed snapshots as the most common research design [14]. This can cause a problem because some important social concepts like poverty (and food insecurity that goes hand in hand with poverty) are dynamic, meaning that people move into and out of poverty/food insecurity. To monitor this dynamic and the role of natural resources (regardless of their governance system), there is a need for longitudinal studies over time instead of single-time snapshots [62].

Regarding the main themes that emerged in this review, that most studies on the impacts of PAs on food security were explanatory studies with a snapshot design, with no control or baseline, it should be noted that impact evaluation is widely used in development, health, and education studies to measure the causal effect of the specific intervention [61]. However, despite its importance, the conservation literature of impact evaluation is relatively small [14]. Some researchers [61] argue that the most important barriers to adopting impact evaluation in conservation are multiple desired

outcomes at different scales that make it difficult to define a clear theory of change to achieve the objectives. In addition, because of the energy and material cycle in the ecosystem, there are usually spatial spillovers and calculating the net impact of conservation in a specific area is a challenge. Difficulties to define confounding factors and the fact that confounding factors have the potential to mask or mimic the causal relation [63], the limitations regarding randomization due to ethical or practical concerns and the small size of conservation initiatives are among other challenges of adopting impact evaluation in conservation [61].

Finally, our results show spatial data and analysis are under-utilized in this topic. The importance of spatial analysis is rooted in the fact that conservation like development is an inherently spatial issue [64]. Studies show that the relationship between PAs and the nutritional status of people living around them is spatially structured and localized [57], as the share of PAs in human nutrition decreased when the distance increased [30]. Hence, the application of spatial data and analysis can help us towards a better understanding of PAs-food security relationships.

Achieving the goals of sustainable development such as food security and biodiversity conservation requires innovative approaches that promote synergies rather than trade-offs. However, this review shows that the relationship between PAs and food security remained understudied in academia. Solid research studies with the application of appropriate research methods, to better understand this relationship, can help policymakers to make evidence-based decisions to reach the goals of sustainable development.

Supplementary Materials: The following are available online at http://www.mdpi.com/2076-3298/7/10/83/s1, Table S1: The bibliographic information for the studies included in this review.

Author Contributions: Conceptualization, Z.J., Y.-F.L., S.N.; investigation, Z.J.; writing—original draft preparation, Z.J.; writing—review and editing, Z.J., Y.-F.L., S.N.; visualization: Z.J.; supervision, Y.-F.L., S.N. All authors have read and agreed to the published version of the manuscript.

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