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Review Article

Biodiversity conservation through ecologically sustainable strategies

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ABSTRACT

Biodiversity conservation strategies often face backlash from different regions of Globe in between the process of being materialized. Direct wildlife damage alone holds the main reason for these kinds of repercussion. Peoples' attitude towards wildlife is complex, with social factors as diverse as religious affiliation, ethnicity and cultural beliefs, all shaping conflict intensity. Traditional knowledge is vital for sustainability of natural resources, particularly in the light of contemporary research on traditional and formal knowledge systems and demonstrates the value of traditional knowledge for biodiversity conservation. Exploration of probable ecological roles of different sociological mechanisms of people belonging from different cultural backgrounds expressed by their traditional resource practices should open a new prospect on sustainable development agenda. Study must be conducted on the limitations and barriers of legislative implications on different people of cultural belief. Traditional knowledge should be explored first to gather the cultural background of species specific taboos and the goal should be to understand their possible ecological roles as well as to study if they can be used as a tool for the conservation of greater good. These should have a two-fold benefit where capacity building among the people of different cultural beliefs and conservation with sustainable use of these resources would be easier to imply. In this paper, therefore, we intend to review the taboos and cultural philosophies with an eye to the possible mitigation strategies of human-wildlife encounters and to certain if this formula can levitate the capacity and approach of the local people more conservation specific.

Keywords: Biodiversity conservation; Ecology; Animals.

1. INTRODUCTION

According to Henry Bauer: *"Science is a mosaic of the beliefs of many little scientific groups"*, with a variety of perspectives that individual scientists themselves possess and the studied objects bestow on them [1].

The conservation of natural resources now faces exceptional challenge because of the declining ecosystem services which are the direct effect of unmonitored growth and unbarred consumption by human population. The sustainability of the essential ecological processes and life support systems now faces grave danger [2]. Similar studies suggest human-domination on Earth results manifest in

global change [3-5], primarily local and then global extinction of biodiversity [6-7] through a series of cascading events and interruption and sequential disruption of ecosystem functions [8]. Actually, the component analysis, such as cultural factors, social factors, personal factors, should estimate the degree of intensity and these cost ratio of conflict fundamentals are still scarce, hence, marginalization is lacking [9]. Most mitigation studies investigate only the technical aspects of conflict reduction. Although different bypassing strategies has been applied by several conservation biologists, the issue of negative human wildlife interaction has never been solved. Resource distribution and utilization among different people regarding different regions are very much ill-balanced and ecologically troubled, which in terms cumulatively developing threat in security of modern human lifestyle [10]. To avert the threats, natural and social sciences have helped by acquiring and applying knowledge about ecosystem conservation and restoration and by strengthening the policy and practice of sustainable development. Understanding the key factors of human environment relationship with the sustainable use of natural resources should be the main priority and need of the hour [11].

2. AN OVERVIEW OF HUMAN-ANIMAL INTERACTION IN INDIA

Conflicts amongst people and wildlife are the result of financial and political scenes and are especially questionable. Numerous predators do predate prey species that people chase, collect or ranch for utilization or diversion and sporadically they may indeed, even slaughter individuals [12-13]. While people and predators have coincided for centuries, the recurrence of conflicts has developed in late decades, to a great extent due to the exponential increment in human populaces what's more, the resultant extension of human exercises [14-15]. The contention may likewise originate from individuals who have distinctive needs or levels of require, alternate points of view on the world in which they live, and inquiries of authority over assets or control over them. Biological science alone does not give an entire comprehension of or arrangements to the argument. In all actuality, half of the test of tending to the debate is in understanding the dynamics of human life with its social, political, financial, and also legislative complexities. In India, human-wildlife interaction is as diverse as the terrain diversity of the country itself. Different regions have different geographical characteristics that expresses the unlikeness of variety of nature and natural resources. As of India, negative interaction of human and wildlife can be categorized into carnivore, omnivore and herbivore among their different needs with different political areas. In majority of the cases, discord happens around the regions adjacent to forests, where human and wild animals meet with great discomfort. Carnivores regularly cause genuine financial and social misfortunes by lifting domesticated animals, making harm property and general group weakness, and in extreme cases human damage or even death, however this kind of instances remain rare [16-21]. Clashes by and large emerge because of rivalry for sustenance assets or spatial contrariness making direct risk human or carnivore life; however the most widely recognized clash amongst people and carnivores in the Indian subcontinent spins around domesticated animals and dismantling harvested crop in and around reserve areas and buffer areas [22-24]. Studies indicates different geographic regions exhibit different kinds of conflict dimensions; Indian Himalayan region reflects interactions with snow leopard (*Uncia uncia*) exclusively as well as other carnivores whereas other regions like central India and other parts of India explores interaction with common leopard (*Panthera pardus*), brown bear (*Ursus arctos*) and black bear (*Ursus thibetanus*), tiger (*Panthera tigris*) and other small carnivore species like wolves (*Canis lupus*), jackal (*Canis aureus*), dhole (*Cuon alpinus*), wild cats (*Felis silvestris*), civets, mongoose, martens, honey badgers (*Mellivora capensis*) etc. (Table 1) [25].

Individuals' mentalities and resilience for snow leopard changes, contingent on their religious convictions, salary status, instructive level, impression of risk that snow leopards stance to their employment, and the degree of domesticated animals misfortunes they and their group have endured [26-28]. Alarming rate of scarcity of food, fragmented and corrupted habitat areas hold responsibilities for increased human leopard negative interaction [29-30].

Table 1. List of animals involved in negative human-wildlife interactions and their conservation status.

Category	Name	Scientific name	Conservation status
Carnivore	Snow leopard	*Uncia uncia*	Endangered
	Common leopard	*Panthera pardus*	Vulnerable
	Tiger	*Panthera tigris*	Endangered
	Wolf	*Canis lupus*	Least Concern
	Jackal	*Canis aureus*	Least Concern
	Dhole/ Wild dog	*Cuon alpinus*	Endangered
	Wild cat	*Felis silvestris*	Least concern
	Yellow throated marten	*Martes flavigula*	Least concern
	Honey badger	*Mellivora capensis*	Lower risk
Omnivore	Brown bear	*Ursus arctos*	Least concern
	Black bear	*Ursus thibetanus*	Vulnerable
	Wild pig	*Sus scorfa*	Least concern
Herbivore	Asian elphant	*Elephas maximus*	Endangered
	Rhinoceros	*Rhinoceros unicornis*	Vulberable
	Wild buffalo	*Bubalus arnee*	Endangered
	Rhesus monkey	*Macaca mulatta*	Least concern
	Nilgai	*Boselaphus tragocamelus*	Least concern
	Sambar	*Cervus unicolor*	Vulnerable
	Chital	*Axis axis*	Least concern
	Common langur	*Semnopithecus entellus*	Least concern
	Parakeet	*Psittacula krameri*	Least concern
	Purple moorhen	*Porphyrio porphyrio*	NR

In case of prey selection leopards exhibit a wide range of behavioral elasticity, which represents them as suitable surviving dweller in all terrain. Leopards always tend to dwell near the human habitation for easing food capture [31-33], particularly in India where the interface amongst backwoods and provincial inhabitations is a continuum. Bear mauling happens all over India but special focus indicates clustered incidents in Himalayan regions by crop raiding and depredation i.e. livestock lifting [34]. On the contrary, herbivore conflicts are much observed on plain lands rather than rugged terrains of mountainous regions. Elephants remain primarily in focus for their conflict with agricultural men due to the enormous amount of damage and their raiding frequency. Nilgai (*Boselaphus tragocamelus*) and wild pig (*Sus scorfa*) does share a fair amount of damage, while other species as sambar (*Rusa unicolor*), chital (*Axis axis*), common langur (*Presbitys entellus*), rhesus monkey (*Macaca mulatta*) and parakeets (*Psittacula krameri*) are also been accounted for loss in Rajasthan and arid region dominated areas of India [19]. Studies have been done focusing Indian Himalayan Region for carnivore conservation issues as well as other parts of India are also projected with potential conflict threat margin as Karnataka, Bihar, Uttar Pradesh, West Bengal, Assam, Odisha, Madhya Pradesh, Rajasthan, Tamilnadu as per the magnitude of the conflict intensity, due to increased competition between many species of wildlife with humans [35]. This kind of interaction affects negatively in case of elephants, rhinoceros, wild pig, and wild buffalo [36-37]. Rhesus macaque and several birds like parakeet, purple moorhen are also known to damage crops [38].

3. ECOLOGICAL SUSTAINABLE STRATEGIES

3.1. Religious belief

Religious belief can mold human anger/ frustration into co-existing collateral damage and develops the pessimism from such damage into optimism. Such as, depredation by Snow leopard *Uncia uncia* (IUCN: Endangered) of livestock is largely accepted by Buddhist herders from Nepal as they think that it was a due punishment from mountain God [39]. Snakes are often traditionally powerful and benevolent according to Hindu tradition. Popular epic, the Ramayana (composed between 300 BCE and 300 CE), has primary animal characters such as *Jambavan* the bear and *Jatayu* the eagle. Similarly, many Hindu Gods and goddesses have their own *bahanas* (carriers), such as:

a) *Aditya* (Sun God) - seven horses,
b) *Agni* - The Ram,
c) *Brahma* - *Hansa* (swan),
d) *Durga* - the lion,
e) *Ganesha* - the mouse,
f) *Indra* - the elephant,
g) *Subramanya* - the peacock,
h) *Maha Lakshmi* - the owl,
i) *Saraswati* - the swan,
j) *Shani* - the crow,
k) *Shiva* - *Nandi*, the bull,
l) *Varuna* - Seven swans,
m) *Vayu* - A thousand horses,
n) *Vishnu* - Garuda.

Rishi Valmiki wrote an epic named the Ramayana, where several characters were expressed as animal totems like Jatayu - the eagle, Hanuman - the monkey and Jamvaban - the bear. Laxmana, brother of lord Rama, according to the epic Ramayana, was a human incarnation of Adishesha, the serpent. Lord Vishnu himself rested upon the coiling of Adishesha [40]. Keeping these factors in mind management strategy and mitigation policy makers should infer their trades. Religions have been dominating people since the very inception of human civilization. The people dwelling in the mountains or in remote areas with lower income and lesser knowledge, can be reminded their religious believes for these animals and their traditions as well as they can be trained for the ecological roles.

3.2. Peoples biodiversity register

The Peoples Biodiversity Register (PBR) process helps to record and promote an assessment of possible value of variety of conservation oriented traditional resource use practices [41]. These practices include the protection of biodiversity of an area as an whole, as well as the communities as sacred groove, on a perspective value "Broad to Specific", i.e., conservation practices can be implied on a whole natural resource of an exclusive area which is in broader scale to specific resource like species. Earlier discarded as superstitions of no practical value, they are now largely accepted with their possible progressive value and their proper documentation through the PBR process would be an important process in their rehabilitation where appropriate [42]. As described by Berkes et al. [43], *"social restraints, such as taboos, that lead to indigenous biological conservation. These restraints include providing total protection to some biological communities, habitat patches, and certain selected species, as well as protection of other species during critical stages of their life history."*

3.3. Strategies related to land and water protection and management

Conservation of land and water seeks diverse management issues which are generally handled by combined partnership of both environmental factors by a single authority. Managing those natural resources need to defining pillar variables or indicators of respective ecosystem services and then those variables should be taken within acceptable parameters [44-45]. At different sites, ecosystem functioning may change in so much dynamic conditions that exclusive assessment of deviation from its pristine habitat differ from historic references of individual sites [46]. While bringing the conflict mitigation policies to their implementations, cultural values for the animals to the people residing at the ground level may have been crucial factors which have been neglected from the very beginning. Ecological restoration practices is observed in different communities on a large spatial scale, which reflects the zoo-geography, cultural belief, resource availability and gives basic idea about that individual site. Till date, many management

strategies are made following those traditional historic data as a guideline. Management strategies to be made based on stored prior information, focus can be given to specific community or group of species rather than a flagship species, which tends to be too much mainstream [47].

3.4. Taboo specific conservation - controlled access of natural resources

Taboos related to the natural environment initially may not have been intended for nature conservation. Primarily taboos may not be was implied because of conservation issues. For example, many species is avoided due to their behavioral or morphological peculiarity [19] or that they might be toxic which they show with explicit warning coloration (Aposematism) [48-49]. In certain cases, such avoidance of broader or specific perspective comes in handy as a perfect outcome of conservation value. Sacred grooves are very good example of this. Sacred grooves hold high religious values to their adjacent common people of exclusive cultural belief and they themselves become an ecosystem [50]. Due to their cultural belief resource utilization form that exclusive forest habitat patch is tenured, i.e., controlled access of resources which leads to a non-systematic sustainable use procedure. To maintain the crop cycle running throughout the year, among some societies in Oceania, custom was incorporated to impose taboos on consecutive crops to avoid harvesting in unsuitable timing [51]. Taboos are used as conservation tools for many societies in order to prevent overexploitation. Many studies show taboos imposed on marine animals to arrest random exploitation of marine natural resources [52]. Some studies suggest that these kinds of taboos which are used as a tool in traditional conservation practices may be a resultant of co-existence of human and their exclusive ecosystem [53]. People belonging from different cultural background has different aspect of seeing nature, and conflict exemplify underlying inter human incompatibility which results in passive venting as human - wildlife conflict. Human and their exclusive niche subsequently develop a reciprocation system over a prolonged period of co-existence, which resulted into modified human behavior as a maintained natural resource exploitation, factually, sustainable development. This, on the other hand, benefits human Community who is particularly living on that habitat patch, as well as other species. So, such practices must cover a diverse resource utilization regimes, which indirectly benefits species biodiversity conservation [54]. There are also different theory arose where it says that species are protected by species-specific taboos, as they were generated via religious or cultural beliefs [55]. On finding the answers of sustainable development strategies prologue, it should not be a research topic on why a species is avoided but to find the possible ecological roles of such practices, which in turn will suffice the need of progressive sustainability science development. Although, it can be fairly said that, species specific taboos directly effects conservation science on the mean of either avoidance or on the basis of religious or cultural basis.

3.5. Effect of indigenous people

Approximately 7 billion people are living on one-fifth of surface of the Earth (2011) [56]. In India, 1.25 billion people are residing (2013). Indigenous people have the most involvement with nature and natural resources as they are the one who have constant access to them. So prioritizing their efforts and natural use practices and direct critical analysis of their regimes should sprout positive results. Their direct involvement on conservation issues should boost-up the sustainable resource use [57]. Indigenous people, adjacent to protected areas living over a lengthened amount of time have the proper knowledge of local systems. Forest level conservation by these local people includes sacred grooves, temple forests, sacred corridors, sacred trees, sacred gardens, water sheds etc. Such long term persistence of conserving exclusive habitat has slowly developed into an honorary custom that directly reflects their conservation management of ecosystem and socio-ecological system. Studies indicate that, persisting sustainable resource utilization practices by local people can increase the richness of species diversity among the individual habitats [58-59]. Ill management and disobeying (not following) the folk knowledge of respective

regions on a large spatial scale in turn affects the biodiversity and resource loss.

3.6. Animal totem and symbolism: increased awareness of co-existence

Animals afford us visions of how our lives could be if we lived more simply and lived with purity of thought and emotion. Therefore, incorporating animal totems into our lives affirms our spiritual goals. Animal totems play huge roles in our lives. They aid in self-discovery and capture our imagination, giving us incredible avenues of self-expression and awareness. By focusing on the attributes of our totems, we internalize these traits and thus begin to externalize the very character we absorb from our totems. For instance, animal totems used as national symbols of any country generates a different level of honour and respect about those animals in the fellow countrymen which can act as a huge motivator for the conservations of those animals.

National Emblem of India: Lion (*Panthera leo*)

National animal of India: Royal bengal tiger (*Panthera tigris*)

National aquatic animal of India: Gangetic dolphin (*Platanista gangetica*) is said to represent the purity of the holy Ganga River as it can only survive in pure and fresh water.

National bird of India: Indian peacock (*Pavo cristatus*) is designated as the national bird of India.

The large diversity of Indian published stamp (Table 2) covers a large area of the landscape involving different region, culture and society. People from different cultural background can satisfy themselves by accepting their totem and should learn or develop reciprocation with other animals also, which previously was precluded but eventually a mutual generic understanding may open a new door. Already marketing and popularizing the trends by issuing postal stamps from government sector, and also various conservation efforts given by several NGO's on different animals, cover a whole spatial range of all India, already have a step closer to introducing those as Flagship species. Flagship species, the term is linked to the metaphor of representation. In its popular usage, flagships are viewed as ambassadors or icons for a conservation project or movement. This species of animals can be used as the focus of a broader conservation marketing campaign based on its possession of one or more traits that appeal to the target audience. Attracting audiences from early age can have some added value as they can develop man and wildlife co-existing outlook and the knowledge can be passed on the next generation with some stringent value. Key factors develop on a child's mind and may can be innate, the "biophilia hypothesis" [60]. The biophilia hypothesis expresses that children who are aged below eight years are strongly affectionate to animals. Again, children aged from eight years to twelve years has got the most significant period that get to know animals closely via several degree of acquaintances like-outdoor interaction, learning via educational media via several stories and books and electronic media shown on television.

Endorsing student learning procedures comprising stories and tales of co-existence will eventually result in a positive mind-set of a new generation. Steps should be taken also to educate elders by developing understanding towards animals not only from own region but also from different regions.

3.7. Environmental ethics

Bisnoi community suggests compassion to wildlife, and forbid felling of *Prosopis cineraria* trees found in Rajasthan. *Bisnoi* teachings proclaim: "If one has to lose head (life) for saving a tree, know that the bargain is inexpensive" [61]. Similarly, tribal communities, those who belongs to Meghalaya like - *Khasi*, *Garo* and *Jaintia* have a history of biodiversity conservation in India which is based on religious beliefs.

Other parts of India also has several events marked as a token to conservation science, where local tribe announces some exclusive forest or habitat patch as customary Sacred groove where resource utilization is strictly prohibited. Study and references show that those areas become (subsequently) or remain bio diverse as an undisturbed habitat patch.

Table 2. List of animals portrayed in Indian National Postage stamps.

Name of the animal	Date declared on	Current IUCN status
1. Royal bengal tiger (*Panthera tigris*) National animal of India	• Issued in 1963 in preservation of wildlife series, • Definitive issued in 1975 • Issued in 1976 to mark Jim Corbett Centenary, • Issued in 1983 to mark 10 years of Project Tiger, • Sundarban National Biosphere Reserve (Issued in 2000 wildlife definitive series), • White Tiger of Rewa issued in 1987	Endangered
2. Asiatic lion (*Panthera leo*)	• 1963 preservation of wildlife series , • 1976 of wildlife series, • A set of four stamps published on 1999 on endangered species: Asiatic Lion	Vulnerable
3. Indian elephant (*Elephas maximus*)	• Issued in 1963 in preservation of wildlife series • Issued in 1986 to mark 50 years of Corbett National Park	Endangered
4. Indian rhinoceros (*Rhinocerus unicornis*)	• Issued in 1962 to mark Wildlife Week	Vulnerable
5. Gaur or Indian bison (*Bos gaurus*)	• Issued in 1963 in preservation of wildlife series	Vulnerable
6. Himalayan red panda or Cat-bear (*Ailurus fulgens*)	• Issued in 1963 in preservation of wildlife series	Endangered
7. Leopard (*Panthera pardus*)	• Issued in 1976 wildlife series	Vulnerable
8. Snow leopard (*Uncia uncia*)	• Issued in 1987	Endangered
9. Clouded leopard (*Neofelis nebulosa*)	• Issued in 2005 in the series Flora & Fauna of North East India	Vulnerable
10. Caracal (*Felis caracal*)	• Issued in 1976 wildlife series	Least Concern
11. Leopard cat (*Prionailurus bengalensis*)	• Issued in 2000 wildlife definitive series	Least Concern
12. Swamp deer or Barasingha (*Cervus duvauceli*)	• Issued in 1976 wildlife series • Issued in 1983 to mark 50th anniversary of Kanha National Park	Vulnerable
13. Kashmir stag (*Cervus elaphus*)	• Issued in 1982 to mark Wildlife Conservation	Least Concern
14. Sangai deer (*Rucervus eldii*)	• Flora and Fauna of Manipur and Tripura issued in 2000	Endangered
15. Chital or Spotted deer (*Axis axis*)	• Definitive issued in 1967 • Definitive issued in 1974	Least Concern
16. Black buck (*Antilope cervicapra*)	• Issued in 2000 wildlife definitive series	Near Threatened
17. Markhor (*Capra falconeri*)	• Himalayan Ecology set of four issued in 1996	Near Threatened
18. Mishmi takin (*Budorcas taxicolor*)	• Issued in 2005 in the series Flora & Fauna of North East India	Vulnerable
19. Nilgiri tahr 20. (*Nilgiritragus hylocrius)*	• Issued in 2000 wildlife definitive series	Endangered
21. Golden langur (*Presbbytis geei*)	• Indian Primates set of two issued in 1983	Endangered
22. Lion tailed macaque (*Macaca silenus*)		

Name of the animal	Date declared on	Current IUCN status
23. Slow loris (*Nycticebus coucang*)	• Flora and Fauna of Manipur and Tripura issued in 2000	Vulnerable
24. River dolphin (*Platanista gangetica*)	• Endangered Marine Mammals set of two issued in 1991	Endangered
25. Sea cow or Dugong (*Dugong dugon*)		Vulnerable
26. Gharial (*Gavialis gangeticus*)	• Issued in 1986 to mark 50 years of Corbett National Park	Endangered
27. Batagur terrapin (*Batagur baska*)	• Endangered Species issued in 2000	Critically endangered
28. Olive ridley turtle (*Lepidochelys olivacea*)		Vulnerable
29. Green or Bamboo pit viper (*Trimeresurus gramineus*)	• Issued in 2003	Least Concern
30. Gliding snake (*Chrysopelea ornata*)	• Issued in 2003	Least Concern
31. King cobra or Hamadryad (*Ophiophagus hannah*)	• Issued in 2003	Vulnerable
32. Python (*Python molurus*)	• Issued in 2003	Vulnerable

Reference of 79 sacred grooves can be found which holds almost 514 species belonging from 340 genera and 131 families [62]. Studies have shown that biodiversity and stability of species is higher and more balanced in sacred grooves than those of the other protected forest habitats which are disturbed for resource utilization.

Different state of India holds different state animals, birds and flowers which pool a large and diverse bio resource. This kind of cultural ethnicity reflects mindset of conservation attitude to different species. If all the resource pool conservation management can be merged together, a fair amount of species conservation effort can result in restoring a huge diversity. The lacking part is the proper commercialization and marketing of the idea to common people to whom it matters most.

Cultural ethnicity can add more value via artworks. Like, in parts of Rajasthan, people do various kinds of artifacts in their households (wall, floor). They paint, which also consists several animals. Promoting these kinds of practices should arise concerns about Indian Heritage and Historic significances of Man-animal relationship running since Harappa-Indus civilization, and then the Kings and their association with Horse and elephants and, which now delimits itself to domestication or pet animals like dogs and cats. Now the debate is which one is a better practice - domestication or active wildlife conservation.

4. CONCLUSIONS

Resource utilization varies biogeographically all over the World. People from different regions around the Globe have their own perspective to exploit their own niche along with the abundance and richness of diversity. Traditional societies do have varied ways of extracting resources, which is in urgent need to be analysed in order to pertain combined mechanisms of sustainable resource exploitation. Possible ecological significance of different resource utilization can be a possible outcome in the de facto of thorough traditional resource modifications. Generating awareness in local people about the diversified resource they have got should have a global perspective for the betterment of mankind and sustainable science.

AUTHOR'S CONTRIBUTION

DG has conceptualized, lead the study and prepared the manuscript. PC has helped in preparation of the manuscript. KM has helped in data gathering and

preparation of the manuscript. The final manuscript has been read and approved by all authors.

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Authors have declared that no conflict of interests exists.

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Research Article

An assessment of potential contributions of agroforestry to food security in Katsina, Sudan Savannah Area, Nigeria

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ABSTRACT

This finding assessed the potential contributions of agroforestry practices to food production in Sudan ecological areas of Katsina State, Nigeria. Multi-stage and purposive sampling designs were used to collect data from three hundred and sixty (360) rural farmers with structured questionnaire administered in nine Local Government Areas of Katsina State. The data were analyzed using descriptive and inferential statistics. The study result showed the socio-economic attributes of farmers in the rural areas, farm size, land ownership, types of crops and trees plant and the perceived benefits of agroforestry practices. This study showed that most of the respondents' primary occupation was farming and they acquired land by inheritance. The major farm yields were food crop production (71.9%), livestock (9.1%), tree crops (2.2%) and combinations of these crops (16.1%). The common agroforestry practices by the respondents were windbreaks, multipurpose trees on farmland and woodlots. The contribution of agroforestry practices in the study area included provision of fruits and leaves, improvement of soil fertility, erosion control and provision of fodder. Most of the respondents reported an increased yield of food crops from a mixed tree and crop farm. Agroforestry practices increase quality of the soil with important nutrients and prevent soil erosion resulting to high crop production. Thus, adoption of agroforestry practices on farmland in the study area would greatly boast food production and soil nutrients.

Keywords: Agroforestry; Food security; Production; Soil conservation; Farmland.

1. INTRODUCTION

Agroforestry is a form of land use that successfully satisfies the needs of the crop farmers, foresters and livestock farmers [1]. King [2] defined agroforestry as a sustainable land management system which constitute the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population. Agro-forestry has a large and important role to play in improving present and future food security worldwide. Although a great deal remains to be understood about the specifics of this role.

Trees have been an integral part of the food security strategies of rural people for so long that it is curious and disturbing to note how trees have often been neglected in the planning of agricultural activities. Even more disturbing, agriculture and

forestry have often been, and sometimes still are, viewed as being in opposition. Some Farmers still have the outdated view that forestry is concerned only with raising timber trees on government lands and agriculture only involves growing crops in open fields [3]. Most farmers have long recognized the importance of trees. They almost invariably incorporate trees in production systems in areas where they have lived for an extended period of time [4-6]. Trees and forests play a critical role in ensuring sustained agricultural production.

Trees are also used to protect crops from wind damage. For example, in the Antilles, Argentina, China, India, the Niger, Papua New Guinea and Tunisia, the use of trees as shelter-belts has resulted in increases in grain production ranging from 30% to 200%. In Nigeria, China, India, Mauritania, the Niger, Senegal and other countries, trees are being used to stabilize dunes and protect soils from being covered by sand [3].

The use of trees in cropping systems is not limited to the production of food crops. For example, Costa Ricans plant trees to give shade necessary in the production of coffee and several other crops; Cameroonians use natural forest for the same purpose. Trees are also an important source of fodder for the animals of the world's 30-40 million pastoralists. In the Sudano-Sahelian zone, *Faidherbia albida* (*Acacia albida*) provides 30-40% of all livestock feed in the dry season [7], while in Mexico *Prosopis* spp. is the main dry season fodder. Seventy-five percent of all indigenous tree species in tropical Africa are used for browse [8]. Under special circumstances, trees also have a role in supporting fisheries, thus ensuring a major food source for many coastal populations [9].

Agroforestry systems were thus classified into system's structure (composition and arrangement of components), functions, socio-economic scale of management and ecological spread. There are only three basic sets of components that are managed in all agroforestry systems, namely: woody perennials (usually referred to as "trees"), herbaceous plants or "crops" and animals. A logical step is to classify agroforestry systems based on their component composition [10]. Thus, there are three basic types of agroforestry systems viz:

i. Agrisilviculture (Crops + Trees);
ii. Silvopastoral (Pasture/animal + Trees) and
iii. Agrosilvopastoral (Crops + Pasture + Trees).

The varieties of agroforestry systems practiced in Nigeria include: *Taungya* farming, integrated *Taungya*, improved fallow in shifting cultivation, alley-cropping (hedgerow inter-cropping), alley farming, shelterbelts, windbreaks, homegarden, multipupose trees on cropland (trees on farmland or farm forestry), trees in soil conservation, aquaforestry, apiculture (apisilviculture), protein bank [11].

The general objective of this study was to evaluate farmers' use of agroforestry practices in the study area with a view to assess the contributions on food production. Agroforestry system as one of the practices that would enable the environment to recovered from extensive cropping systems. It is expected that this study will assist agricultural planners and policy makers to properly address the issue of food sufficiency and environmental degradation.

2. MATERIALS AND METHODS

2.1. The study area

This study was carried out in Katsina state within the Sudan savannah ecological zone of Nigeria. Katsina State lies on latitude 12 ^{0}N and longitude 8 ^{0}E. North east trade wind predominate Katsina state between Novembers to March yearly. Rainfall is experienced in this area between June to September, with mean annual rainfall from 1000 mm to 1200 mm. The state on the whole has a mean annual rainfall of about 840 mm. Mean relative humidity is lower than 50% in January and February and could be as high as 80% in June – July. Temperature range is often from 38^0-41^0C.

2.2. Data collection and statistical analyses

Multi-stage and purposive sampling designs were used in the study. Nine Local Government Areas (LGAs) were randomly selected out of the 34 LGAs in Katsina state. Forty (40) copies of questionnaire were administered to rural farmers in each LGA; given a total of a sample size of 360. Data gathered include: respondents demographic attributes, source of farm land, labour, farm size, agricultural activities, types of crops and trees plant,

estimated farm yield and income, source of information and the perceived benefits of agroforestry practices. The data obtained from the study were analysed, using descriptive statistics (frequencies and percentages) and inferential statistical techniques (correlation analysis, ANOVA). Results were presented in tables and graphs for clarity.

3. RESULTS AND DISCUSSION

3.1. Demographic attributes of the respondents in Katsina State, Nigeria

Majority of the respondents (95.2%) in the study area were married men and women and 4.8% were single. Most marriages were polygamous and had an average of more than seven children that provided labour force for farming. Respondents' gender showed that there were more male (95.80%) than female (4.20%) farmers from the study area. This implies that the male genders were mostly involved in agroforestry practices as compared to females. Generally, farming is mostly practices by the males in the study area. This may be as a result of the strenuous nature of most farming activities in general and agroforestry practices in particular. These activities are not attractive to women who often engage in domestic work. The fewer number of women in agroforestry practices might also be attributed to the culture and religion of the people in the area; this made access to women by male extension agents difficult since there were very few women extension agents.

Most of the respondents in the study area were between 25 and 50 years of age. The age distribution is an important factor in farming activities because it affects the work force and decision-making in farming activities. The dominant age bracket among rural dwellers in the study was an indication that this was the age bracket that was actively involved in agroforestry practices.

Majority of the respondents (55.5%) acquired Islamic education as the highest educational attainment, followed by primary education with 20.6%. Based on the result in the study area, educational level of the rural dwellers was low. However, on average, Islamic education recorded the highest percentage, followed by primary education. The study also revealed that with the low level of western education, the respondents had knowledge and high level of awareness on tree species, shrubs, herbs and other agroforestry practices. This knowledge influence their perception and willingness to participate in agroforestry practices. They still needed more enlightenment and training on modern agroforestry techniques as a means of sustainable land management. Farming was the major occupation in the three ecological zones of the study area as obtained from the results. The study showed that 64.5% of the respondents were farmers while 35.5% of the people engaged in trading, civil service and cattle rearing among others.

3.2. Respondents' farm size and tenure system in the study area

Table 1 shows the farm size per hectare and the frequency of respondents from the study area. Percentage of respondents from each location was obtained based on the administered questionnaire in each location from the three ecological zones of the study area. Thus, more than half of the respondents (59.7%) had farm sizes of 0.5-4 hectares and 23.9% had farm size greater than six hectares based on the result obtained (Table 1). This shows a low income status on farmers who farm mainly for household consumption and to earn very little income. This could be one of the reasons for continues abject poverty among the rural dwellers in the study area.

Based on this finding, majority of the respondents were engaged in subsistence farming which was mainly for household consumption and very little for sale due to the small size of farmland (0.5-4 hectares). This explains why most of the peasant farmers cannot make enough profit from their produce and therefore remain poor lacking purchasing power enough to maintain a minimum standard of living.

The study result showed that 48.4% of the respondents acquired their farmlands through inheritance from parents and relatives (Table 2). Other respondents acquired land through purchase (9.2%), lease (2.9%) and government (0.7%). While, 37.2% of the respondents acquired their land through a combination of two or more of these land tenure system. Based on the study result, majority of

the respondents acquired farming land through inheritance. This finding agrees with Adekoya [12], which reported that land ownership in the forests is generally acquired through group inheritance. In descending order, other respondents acquired their land through purchase, rental and government respectively. There is no land in the country that is not owned either by individual, community or government. Under the traditional land tenure system, occupant of rented land cannot dispose of it or put into use for permanent tree crop cultivation. Apart from inheritance, acquisition of land through government and purchase remain more permanent for farmers using agroforestry practices.

Table 1. Farm size of the respondents in the study area

Farm size (ha)	Frequency	Katsina north (%)	Katsina central (%)	Katsina south (%)	Mean (%)
0.5-2	114	50.8	15.8	28.3	30.4
3-4	101	22.5	24.2	37.5	29.3
5-6	59	9.2	19.2	20.8	15.5
>6	86	17.5	40.8	13.4	24.8
Total	360	100	100	100	100

Table 2. Tenure system by the respondents in the study area

Land tenure system	Frequency	Katsina north (%)	Katsina central (%)	Katsina south (%)	Mean (%)
Inheritance	184	51.1	35.8	58.3	48.4
Purchase	45	12.5	7.5	7.5	9.2
Multiple system	104	28.9	51.7	30.9	37.2
Government	8	2.2	0	0	0.7
Gift	6	1.7	0.8	2.5	1.7
Lease	13	3.6	4.2	0.8	2.9
Total	360	100	100	100	100

Table 3. Respondents' major agricultural outputs and livestock reared in the study area

Farm output	Frequency	Katsina north (%)	Katsina central (%)	Katsina south (%)	Mean (%)
Tree crops	8	4.2	1.7	0.8	2.2
Timber crops	2	1.7	-	-	0.7
Food crops	259	75.8	53.3	86.7	71.9
Livestock	33	11.6	7.5	8.3	9.1
Multiple output	58	6.7	37.5	4.2	16.1
Total	360	100	100	100	100

3.3. Agricultural farm produce and livestock reared in the study area

Majority of the respondents (71.9%) were involved in food crop production with 9.1% reared livestock, with 0.7% of the people engaged in planting timber crops while 2.2% planted tree crops. Also, 16.1% of the respondents produced more than one crop in the study area (Table 3).

The major livestock reared in the study area are presented in Table 4. Cattle, goat, sheep and poultry were some of the major animals reared in

the area. Sheep production accounted for 26.4% with goat and cattle had 12.5% and 11.9% respectively; while majority of the respondents (45.9%) reared multiple (two or more) livestock. Poultry production was low in the study area. The result showed that sheep were the most favoured livestock reared. The high production of sheep in relation to goat production may be due to the preference of the farmers for sheep consumption during sallah period.

Table 4. Domestic animals reared in the study area

Major livestock	Frequency	Katsina north (%)	Katsina central (%)	Katsina south (%)	Mean (%)
Goat	45	23.3	9.2	5.0	12.5
Sheep	95	43.3	10.0	25.8	26.4
Poultry	12	5.0	4.2	0.8	3.3
Cattle	43	21.7	10.0	4.2	11.9
Multiple livestock	165	6.7	66.6	64.2	45.9
Total	360	100	100	100	100

Most of the respondents (94%) agreed that tree planting prevented soil erosion and increases soil fertility, while 5.8% did not agree with the role of tree plants in soil fertility and erosion control. This result is in accord with Skole et al., [13] and Torquebiau [14], which reported that in addition to increasing soil fertility, trees managed by farmers can also provide ecosystem services and functions in addition to the products and services that motivated farmers to plant or preserve them

Most of the respondents 86.0% of the respondents agreed that tree and food crops combination could sustain farm resources while 14.0% had negative perception on this. According to this findings, 90.2% of the total respondents agreed that combining plant trees together with food crops ensures continuous land utilization, 9.8% of them disagreed with the statement. This result agrees with Garrity et al. [15], which reported that in recent time, there is an increase in adoption of Agroforestry by farmers in many parts of Africa. In spite of these successes, adoption has not been widespread in many parts of Africa, due to a number of reasons related to the performance of agroforestry practices, the political and socio-economic environment or simply farmers' disposition towards trees on their farms.

The respondents (93.6%) perceived that agroforestry practices help to improve farmers' income with 6.4% of the respondents had a negative perception. While 90.3% of the people agreed that combining plant trees together with food crops greatly influence agricultural yield and also help to preserve the environment, 9.7% disagreed with this statement. Most of the respondents were of the opinion that combining tree plants with food crops could reduce the risk of complete crop failure and 8.7% of the respondents did not agree with the statement. This result agrees with Cheikh et al. [16], which reported that in light of recurring food shortages, and rising prices of fossil fuel-based agricultural inputs, agroforestry has recently experienced a surge in interest from communities, as a cost-effective means to enhance food security, while at the same time bring income to the people.
Majority (93.8%) of the respondents were of the view that planting trees and food crops together contributes to the provision of fruits and leaves and 6.2% of the respondents disagreed. The farmers (94.2%) responded that there is a significant yield from a mixed tree farm and a pure crop farm, while about 5.8% had a negative response. Majority of the farmers (95.5%) agreed that there is an increased of organic fertilizer on their farmland result of present of tree plants (agroforestry trees). This finding is in accord with Cheikh et al. [16], which reported that many smallholder farmers in Sub-Saharan Africa practice agroforestry. These systems have prevailed despite persistent attempts to introduce monoculture production of annual crops, which have been much less successful in Africa than elsewhere.

The most common tree species combined

with agricultural crops in farmland among the respondents in the study area are show in Table 5. The result showed that *A. indica* was the most common tree planted with crops in farmland follow by *A. digitata*, *M. indica*, *T. indica* while *B. aethiopum* and *L. inermis* were among the least tree species. This finding agrees with Thangataa and Hildebrand [17], which reported that agroforestry practice has been shown to provide a number of benefits to farmers, for instance, it can enhance soil fertility in many situations and improve farm household resilience through provision of additional products for sale or home consumption.

Table 5. Cultivated tree species with agricultural crops in the study area

Tree species	Common name	Family	Frequency	Percentage (%)
Borasus aethiopum	-	Palmae	3	0.8
Adansonia digitata	Baobab	Bombaceceae	48	13.6
Mangifera indica	Mango	Anacardiaceae	35	9.9
Lawsonia inermis	Lalle	*Lythraceae*	5	1.4
Vitex doniana	-	Verbenaceac	31	8.8
Termarindus indica	Termarind	Fabaceae	32	9.0
Delonix regia	Flambouyant	Caesaipiniaceae	44	12.4
Cassia siamea	Cassia	Caesaipiniaceae	16	4.5
Azadirachta indica	Neem	Meliaceae	58	16.4
Dalbergia sissoo	Dalbergis	Papilionaceae	24	6.8
Ziziphus mauritiana	-	Rhamnaceae	6	1.7
Balamites aegyptiaca	-	Balamitaceae	52	14.7
Total	-	-	354	100

3.4. Rate of crop production under agroforestry and non-agroforestry farmlands in the study area

Table 6 show the crops produced under agroforestry and non-agroforestry farmlands in the study area. The crops include: cowpea, maize, guinea-corn, millet, wheat and rice. The yields from agroforestry and non-agroforestry farmlands were compared. The ANOVA result showed that the crops were significantly different ($P \leq 0.05$) with higher crop production obtained from agroforestry farmlands than from non-agroforestry farmlands.

Crops grown in the sampled farmers' farmlands in the agroforestry and non-agroforestry farmlands are shown in Table 6. This findings showed that the yield of agricultural crops were significantly different with higher yield for agroforestry farmlands compared to non-agroforestry farmland. Agroforestry systems aim to maintain or increase production as well as productivity of the soil [18]. The higher yields of crops obtained from agroforestry farmlands could be as the influence of the agroforestry practices to soil organic matter, nutrient cycling, soil fertility, soil organisms, weeds and pests control [19]. The adequate supply of nutrients is essential to a sustainable system of agroforestry. For poor soil nutrients in the tropical region of Nigeria, crop productivity may be increased by use of inorganic fertilizers. The soil fertility of agroforestry farmlands was generally higher compared to non-agroforestry farmlands. The impoverished of the non-agroforestry farmlands could be attributed to continuous cropping observed in the study area. The insight that trees on farms provide livelihood benefits is not new, and diversity-based approaches to agricultural adaptation to climate variability have been adopted by many farmers [20].

Table 6. Crop production on agroforestry and non-agroforestry plots in the study area

Crops	Farmland	Mean yield (kg/ha^{-1})	T. value	P
Millet	Agro-forestry	1072.21	5.10*	0.000
	Non agro-forestry	666.76		
Maize	Agro-forestry	1129.31	11.35*	0.000
	Non agro-forestry	810.00		
G/corn	Agro-forestry	825.00	4.65*	0.000
	Non agro-forestry	660.67		
Rice	Agro-forestry	1005.09	6.10*	0.000
	Non agro-forestry	850.32		
Cowpea	Agro-forestry	680.33	353*	0.028
	Non agro-forestry	3940.42		

* = Significant

4. CONCLUSION

Based on this finding, agroforestry practices contribute to food production in the face of economic recession and land degradation. The practices enrich the soil with nutrients and minimize soil erosion and degradation. Wealth knowledge of multipurpose trees species on farmland will burst food production and help in preventing nutrients depletion and desert encroachment in the study area. Therefore, it is recommended that more research in tree-based farming systems should be carried out, so that the potential benefits in agroforestry can reach many more farmers throughout Africa in the nearest future.

AUTHOR'S CONTRIBUTION

All authors carried out the research and contributed equally both in financial and technical aspects of the research work. The final manuscript has been read and approved by all authors.

TRANSPARENCY DECLARATION

Authors have declared that no conflict of interests exists.

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