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RESEARCH ARTICLE

A systematic review of resource habitat taboos and human health outcomes in the context of global environmental change

Alexander Angsongna[a], Frederick Ato Armah[b], Sheila Boamah[c], Herbert Hambati[d], Isaac Luginaah[e], Ratana Chuenpagdee[f] and Gwyn Campbell[g]

[a]Department of Linguistics, University of Western Ontario, London, Ontario, Canada; [b]Department of Environmental Science, University of Cape Coast, Cape Coast, Ghana; [c]Arthur Labatt Family School of Nursing, Health Sciences Addition, University of Western Ontario, London, Ontario, Canada; [d]Department of Geography, University of Dar es Salaam, Dar es Salaam, Tanzania; [e]Department of Geography, University of Western Ontario, London, Ontario, Canada; [f]Department of Geography, Memorial University of Newfoundland, St. John's, NL, Canada; [g]Indian Ocean World Centre (IOWC), Montréal, Quebec, Canada

ABSTRACT

The dependence of humans on the ecosystem services that natural resources provide is absolute. The need for social taboos as frameworks for governing natural resource abstraction is gaining widespread recognition especially within the context of climate change. However, the complex relationship between resource and habitat taboos (RHTs) and human health is not entirely understood. We conducted a systematic review of existing studies of the association between RHTs and human health outcomes, focusing on the best evidence available. We searched JSTOR, SocINDEX, Greenfile and Academic Search Complete databases from 1970 to July 2015; and also searched the reference lists of reviews and relevant articles. About 779 studies and data from 26 studies were eligible for the analysis. Only 9 out of 26 studies clearly linked RHTs to human health. Overall, nine taboos, spatial, temporal, gear, method, effort, catch, species-specific, life history and segment, were covered by the empirical studies. This systematic review provides new evidence of relationships between RHTs and human health outcomes. Several methodological limitations were identified in the empirical material. The findings suggest the need for context-specific conservation policies to reduce erosion of RHTs in order to sustain human health in the face of climate change.

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Introduction

Humans and society have depended on natural resources and processes for millennia especially in kincentric societies across the globe. According to Cole, Eyles, Gibson, and Ross (1999) and Colls, Ash, and Ikkala (2009), healthy ecosystems provide drinking water, habitat, shelter, food, raw materials, genetic materials, a barrier against disasters, a source of natural resources and many other ecosystem services on which people

CONTACT Frederick Ato Armah farmah@ucc.edu.gh

depend for their livelihoods. In kincentric societies, indigenous knowledge on environmental change has been shaped by experiences of community members and involves constant learning-by-doing, experimenting and knowledge building (Berkes, 2009). This mode of learning by indigenous people, which usually occurs through interaction with the natural environment, is inextricably linked to culture-space, place, identity and meaning (Berkes, 2009) as well as to experience (Parr, 2010). An intrinsic element of this mode of learning is the continuing emphasis on the complex interdependent nexus between humans and ecosystems. According to the Millennium Ecosystem Assessment, functioning ecosystems provide an immense number and array of services, which are relied on by all components within the web of life, including humans (MEA, 2005a, 2005b; Perrings, 2010). These ecosystem services encompass biophysical goods such as clean water, timber, wild foods, pollination, flood control and carbon sequestration as well as cultural, spiritual, recreational and health benefits (Haines-Young & Potschin, 2010; Levy, Daily, & Myers, 2012; McMichael et al., 2005; Perrings, 2010; Turner & Daily, 2008). During the past half century, while loss of ecosystem services and fragmentation of habitat have been framed as immediate threats to several species at risk in the context of the Anthropocene, the connection between habitat protection and human health and well-being is often overlooked although it is well documented that in areas of high environmental degradation, human health tends to be lower (Corvalan, Hales, & McMichael, 2005; MEA, 2005a; Sandifer, Sutton-Grier, & Ward, 2015).

Lately, there is widespread realisation that climate change and ecosystems are inextricably linked and that healthy ecosystems play important roles in helping people adapt to climate change. This recognition brings into sharp focus the potential adverse effects of a changing climate on the long-term sustainability of ecosystem services. In this context, a logical assertion is that by changing the environmental conditions within which species exist, climate change induces an adaptive response. According to Perrings (2010), studies over the last two decades have described deleterious climate effects on both species and ecosystems (see Lovejoy & Hannah, 2006; Willis & Bhagwat, 2009). Much of this is outlined in the international biodiversity and climate assessments at various scales (see Karl, Melillo, & Peterson, 2009; MEA, 2005a, 2005b; Perrings, 2010; Steffen et al., 2010). Broadly, it has been suggested that climate change is both a cause and an effect of erosion of ecosystem services, and is part of the critical determinants of change in the distribution and abundance of species in both managed ecosystems such as agriculture, production forests, cities and many coastal zones, and natural terrestrial and marine ecosystems (Colls et al., 2009; MEA, 2005a, 2005b; Perrings, 2010; Steffen et al., 2010). Climate change is also an effect of land uses that generate greenhouse gases (CO_2, CH_4, N_2O) and of changes in biological stocks of carbon in terrestrial and marine systems (green and blue carbon). From a conservation standpoint, the critical feature of climate change is that it differentially affects the probability that species will be driven to extinction. In this context, it has been further suggested that the risk of extinction is likely to increase for many species that are already vulnerable (Colls et al., 2009; Thomas et al., 2004); partly due to the time it takes for many species to adjust to climate change (Menendez et al., 2006; Perrings, 2010). While the impact of climate change on extinction probabilities remains a debatable issue (Willis & Bhagwat, 2009), this is the effect that most strongly motivates the conservation community.

According to Colls et al. (2009), beyond the conservation community, there is greater concern for the potential impacts of climate change on the species that most directly benefits agriculture (the production of foods, fuels and fibres) and health (of humans, animals and plants). Informal institutions particularly in kincentric societies hold great potential in conserving ecosystems, the services they offer and, by extension, fostering human health. This is because these institutions (e.g. social taboos) are embedded in indigenous knowledge systems and culture. Social taboos have governed resource use and abstraction for millennia. Yet, the recognition of the usefulness of such taboos as complementary mechanisms to formal institutions in resource conservation by the scientific community is rather nascent (Jacobsen & Stephens, 2009). Colding and Folke (2001) found six categories of resource and habitat taboos (RHTs), which are relevant to resource conservation and management in both Western and non-Western contexts. These include segment taboos, which regulate resource withdrawal; temporal taboos, which regulate access to resources in time; and method taboos, which regulate methods of resource withdrawal. Others include life-history taboos, which regulate withdrawal of vulnerable life-history stages of species; specific-species taboos, which govern total protection to species in time and space; and habitat taboos, which restrict access and use of resources in time and space. There is also a range of religion-specific taboos across the world prohibiting the consumption of certain foods and animals. The success or otherwise of social taboos as frameworks for governing resource abstraction depends on the characteristics of resource users. According to Colding and Folke (2001), these characteristics include clearly defined boundaries of the resource base; congruence between appropriation and provision rules and local conditions; collective-choice arrangements; monitoring systems; graduated sanctions; conflict-resolution mechanisms; minimal recognition of rights to organise and the nesting of local institutions with other local, regional and governmental institutions. This introduces an element of complexity and non-linearity into the structure and function of taboos.

Although there have been studies on RHTs over the past 40 years (see Begossi, Hanazaki, & Ramos, 2004; Colding & Folke, 2001; Fabricus et al., 2013; Foale, Cohen, Januchowski-Hartley, Wenger, & Macintyre, 2011; Folke, Colding, & Berkes, 2003; Jones, Andriamarovololona, & Hockley, 2008; Ntiamoa-Baidu, 1991), what is unclear is the coherent picture of the findings as it relates to the link between RHTs and human health, hence the need for this systematic review. The following research questions were formulated to guide this systematic review: how do existing studies relate RHTs to health? What methods do such studies use in explicating the connection between RHT and health? What is the geographical and population distribution of these studies? The findings of this systematic review will potentially shape future research agenda on the RHT–health nexus.

Methods

Search strategy and study selection

We searched four databases namely JSTOR, SocINDEX, Greenfile and Academic Search Complete from 1970 to July 2015 as shown in Figure 1, using the terms "social taboos" AND "health/conservation/environment/institutions/indigenous knowledge/resource/habitat". In addition, we searched the reference lists of reviews (Colding & Folke, 2001)

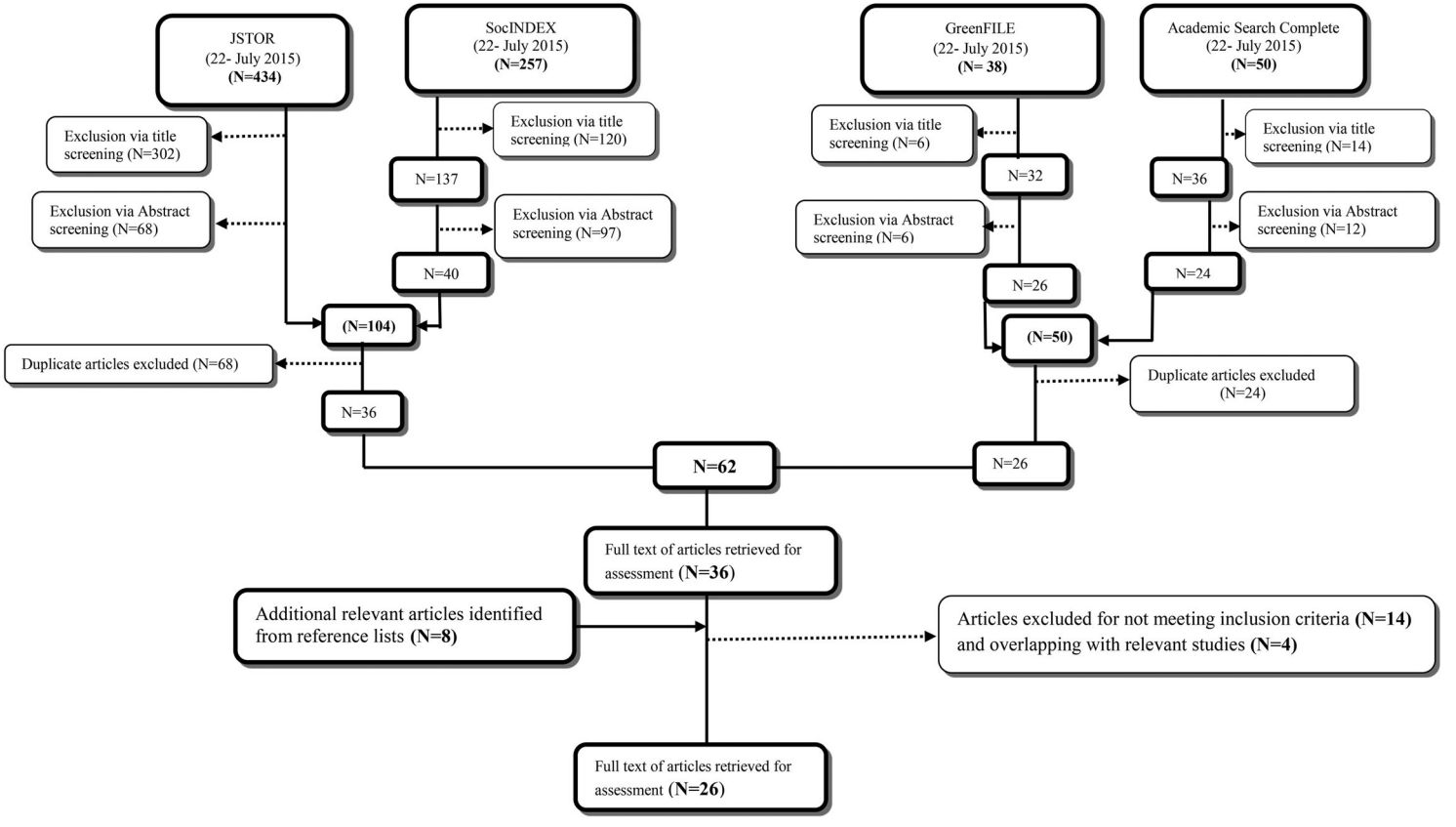

Figure 1. Flow diagram indicating the search strategy and data extraction.

and potential relevant articles. We followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) group (Moher, Liberati, Tetzlaff, & Altman, 2009). Two authors (FAA and AA) independently evaluated the articles. Studies were selected if they fulfilled the following a-priori eligibility criteria: the study was (i) original and presented data on social taboos (segment, life history, species-specific, method, temporal), or natural resource, ecosystems and environment (e.g. wildlife, freshwater, marine or terrestrial habitats), (iii) a cross-sectional study and (iv) narrative reviews of RHTs in the existing literature. If more than one report was published from the same study, the most recent study or the study using the best assessment of RHT and/or health outcome was included. Studies on RHTs for which human health was not explicitly mentioned were also included. This was necessary to ascertain when human health became a central theme in the burgeoning literature on RHTs. Studies on social taboos, which were not unequivocally RHTs were excluded. Our broad health outcomes of interest included protein–calorie malnutrition, maternal depletion, premature aging and general malnutrition in women, prenatal nutrition, physical health (symptoms relevant to zoonotic disease or allergies), mental/psychological health and loss of species of medicinal value.

Data extraction and quality assessment

Most relevant characteristics of eligible studies including study design, study size, location and country of study, method of RHT assessment, types of RHTs and their definitions, year of publication, year of data collection and study results (i.e. measures of association) were recorded in a standard data extraction form independently by two authors (FAA and AA). Any discrepancies were resolved by consensus. To assess quality of eligible studies (Tong, Sainsbury, & Craig, 2007), we applied the consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups given that most of the studies were qualitative. Studies scoring 10 or more were categorised as moderate to high quality.

Results

Study characteristics

Seven hundred and seventy-nine articles were identified from our search. The systematic literature search strategy is shown in Figure 1. Out of these studies, 62 were thoroughly reviewed. Eighteen studies met our initial inclusion criterion and were added to the review. Forty-four articles were excluded due to various reasons. Papers that did not focus on RHTs, not published in English, non-academic (peer-reviewed) and those that did not report any ecological or human health outcomes were excluded. Eight additional relevant studies from the reference list of Colding and Folke (2001) and Meyer-Rochow (2009) were included. Overall, 26 studies were finally retrieved for the systematic review. Out of these, nine studies examined food taboos; 15 studies examined species-specific taboos as well as other taboos; seven studies investigated spatial/segment taboos; temporal taboos were represented in six studies; three studies described life-history taboos and gear/methods were discussed in four studies.

Five studies were conducted in Madagascar; four in Ghana, three in Nigeria, one in Malaysia, one in Mexico, three in India, two in Tanzania; one in six south American countries; one in Brazil; one in California, USA; one study simultaneously covered Malaysia, Papua New Guinea, Nigeria, India and Israel. However, three studies did not specify the countries in which the research was conducted. Most of the studies scored low on the consolidated criteria for reporting qualitative research COREQ due to various reasons (see Table 1).

Food taboos

A food taboo may be defined as a rule forbidding the consumption of part of an animal, the whole animal, a series of animals or any other food stuff. Food taboos may apply to the total population; however, most taboos pertain to specific segments of the population rather than the whole population (McDonald, 1977). Nine studies examined the human health and conservation outcomes of food taboos.

All studies reported various reasons for such food restrictions especially on children, pregnant and lactating women as ranging from health risk, religion and as a conservation measure, especially animals and plants that are considered medicinal. In mid-west Nigeria, several food taboos affect women and children, restricting their protein intake. For example, eggs and meat are not given to children for fear that they would acquire an expensive eating habit, and eventually steal if they cannot afford such foods. In Benin, Igarra, the Delta and Owan divisions, coconut milk and liver must not be given to children because, it is believed that the milk makes them less intelligent. Similarly, in some parts of Ishan, Afemai and Isoko divisions, pregnant women are strictly forbidden from eating snails in order to prevent excessive salivation from the new baby. In other areas such as Benin divisions, fresh meat and oil are not eaten by newly delivered mothers. This is because the meat is believed to be a cause of abdominal pains whereas the oil causes jaundice in the new born baby. Men are also restricted from eating snails in areas like Urhobo and Ika divisions simply because it will decrease men's strength during wars. Beans and vegetables are not eaten in some communities due to abdominal pains associated with them. Generally, men have fewer taboos in mid-west Nigeria. This situation appears to be a representation of a society in which food taboos are imposed to the benefit of a particular group – the strongest or the dominant group.

In west Malaysia, food taboos mainly affect animal source protein. These taboos could be due to various reasons; consideration of food as unclean, poisonous, the fear of harmful effects and special relationship with the food, especially animals. For instance, the Orang Asli do not eat lizards as they are considered unclean; pets like dogs are not eaten because they have gained the trust of humans and so it would be immoral to kill them. Tigers are not eaten because they eat humans and so the Orang Asli believe that tigers have human spirits in them. Pregnant women and children do not eat meat of larger or less commonly caught animals. Such animals are believed to possess very harmful and strong spirits and therefore not suitable for pregnant women and children. It is also believed that if they (pregnant women and children) eat meat of larger animals, they will suffer from "sawan" convulsion. In other tribes in west Malaysia some animals are tabooed because of their hostile and aggressive nature. The Bateq tribe prohibit the consumption of all animals in constant contact with the ground such as snakes and lizards. The Orang Asli

Table 1. Summary of empirical studies included in the systematic review.

Reference, year (Study design/ methods)	Location/study area	Study population/ethnic groups	Duration of study	Number and type of taboos	Outcome studied	Total score based on assessment
1. Jones et al. (2008) (Cross-sectional; mixed methods)	Central eastern rainforests of Madagascar in Fianarantsoa Province of Madagascar	75 households of the Betsileo, Tanala, mixed descent	4 years	5: segment, life history, temporal, species-specific, resource habitat	Conservation, behavioural change, food preferences	7/32
2. Saj, Mather, and Sicotte (2006) (Mixed methods)	Boabeng-Fiema Brong-Ahafo region, Ghana	300 inhabitants of Boabeng and Fiema	15 months	2: Species-specific, resource habitat,	Health, conservation	9/32
3. Golden and Comaroff (2015a) (Cross-sectional; quantitative)	Northeastern Madagascar	861 households; 26 communities of the Betsimisaraka, Tsimihety and extra local group	7 years	1: Wildlife	Conservation	14/32
4. Golden and Comaroff (2015b) (Cross-sectional; mixed methods)	Northeastern Madagascar	818 households of the Bestimisaraka and Tsimihety groups	7 years	2: Food, species-specific	Human health, conservation, environmental risk	14/32
5. Meyer-Rochow (2009) (Review)	Malaysia, Papua New Guinea, Nigeria, India, Israel	Hindu, Jews, Orang Asli, Onabasulu, Mid-west Nigeria	Not specified	2: Food, species-specific	Human health, resource protection	7/32
6. von Heland and Folke (2014) (Mixed methods)	Androy, Tolaria province, Madagascar	Not specified	5 years	1: Wildlife	Resource management and Conservation	8/32
7. Torri and Herrmann (2011) (Qualitative)	Sariska region, Rajasthan, India	35 villages	6 months	2: Wildlife, species-specific	Conservation	7/32
8. Tengo et al. (2007) (Cross-sectional; qualitative)	Southern Androy, Madagascar	Tandroy in Ambanaivo village	2 years	2: Resource habitat, species-specific	Conservation	9/32
9. Baker, Olubode, Tanimola, and Garshelis (2014) (Cross-sectional; mixed methods)	Akpugoeze, Lagwa of Igbo-speaking region of Southeastern Nigeria	410 radomly sampled residents 14 community elders and 7 shrine priests	5 months	1: Species-specific	Conservation	7/32
10. Ntiamoa-Baidu (2008)	Nkodurom, Kwabre-East District, Ashanti region, Ghana Pinkwae sacred grove, Katamanso, Greater Accra, Ghana.	Not specified	Not specified	3: Species-specific, resource habitat, temporal	Biodiversity conservation	4/32
11. Barre, Grant, and Draper (2009) (Cross-sectional qualitative)	Tallensi-Nabdam, Ghana	8 villages, 15 groves, 42 respondents	Not specified	3: Species-specific, resource habitat, segment	Environmental conservation	8/32

(*Continued*)

Table 1. Continued.

Reference, year (Study design/ methods)	Location/study area	Study population/ethnic groups	Duration of study	Number and type of taboos	Outcome studied	Total score based on assessment
12. Kajembe, Luoga, Kijazi, and Mwaipopo (2003)	East Usambara, Tanzania	2 villages; Mwembeni-Magoroto, Potwe-Ndondond. 35 respondents; 63 households	Not specified	3: Resource habitat, segment, species-specific	Environmental and wildlife Conservation	9/32
13. Kideghesho (2008) (Cross-sectional)	Western Serengeti, Tanzania	3 villages; 9 elders (3 from each village)	Not specified	2: Wildlife species, Resource habitat	Environmental and wildlife Conservation,	11/32
14. Cinner and Aswani (2007)	Not specified	Not specified	Not specified	7: Spatial, temporal, gear, method, effort, catch, species-specific	Resource management and conservation	6/32
15. Colding and Folke (2001) (Generic)	Not specified	Not specified	Not specified	6: Segment, temporal, life history, method, species-specific and resource habitat	Resource management and conservation	8/32
16. Khumbongmayum, Khan, and Tripathi (2005)	Manipur, Northeast India	Meiteis	1 year	2: Species-specific and resource habitat	Biodiversity conservation	7/32
17. Ogbeide (1974) (Qualitative)	Mid-west state, Nigeria	27 elderly people of Benin city	Not specified	1: Food taboos	Health risk	8/32
18. McDonald (1977) (Quantitative)	South America	11 societies in 6 countries: Brazil (Northern Kayapo, Yanomamo, Tukuna, Tenetehara, Eastern Timbira, Akwe Sahavante, Desana), Venezuela (Yanomamo), Bolivia (Siriono), British Guiana (Waiwai), Ecuador (Jivaro), Colombia (Desana)	Not specified	1: Food taboos	Conservation of game resources and health	6/32
19. Begossi (1992) (Quantitative)	Buzios Islands, Brazil	39 households in the Buzios islands	13 months	1: Food taboos	Health-related issues and conservation	5/32
20. Rea (1981) (Quantitative)	Sonoran deserts, California	8 ethnic groups (Riverine Pima, Sand Papago, Pima Bajo, Seri, Colorado River Yumans, Maricopa, Western Apache)	Not specified	2: Food taboos; species-specific	Health and conservation	7/32
21. Santos-Torres and Vásquez-Garibay (2003) (Cross-sectional; qualitative)	Guadalajara, Mexico	493 nursing mothers	Not specified	1: Food taboos	Health	11/32

(*Continued*)

Table 1. Continued.

Reference, year (Study design/ methods)	Location/study area	Study population/ethnic groups	Duration of study	Number and type of taboos	Outcome studied	Total score based on assessment
22. Jimoh, Ikyaagba, Alarape, Obioha, and Adeyemi (2012)	Oban Hill, Cross River National Park, Nigeria.	4 villages; Old Netim, Aking, Osomba and Oban	Not specified	4: Species-specific, resource habitat, method and temporal taboos	Health issues and resource conservation	8/32
23. Bolton (1972)	West Malaysia	Orang Asli ethnic group	Not specified	1: Food taboos	Health	5/32
24. Negi (2010)	Uttarakhand, central Himalayas, India	1262 informants	Not specified	3: Resource habitat, species-specific and temporal taboos	Resource conservation	10/32
25. Gadegbeku et al. (2013) (cross-sectional; qualitative)	Ashongman, Accra, Ghana	200 adults	3 weeks	Food taboos	Health and conservation	10/32
26. Colding and Folke (1997) (Review)	Not specified	Not specified	Not specified	Species-specific taboos	Protection and conservation	8/32

believe that all animals possess spirits. Thus, children who are a little over four years usually start with snails, toads, small birds so that they would be able to cope with the spirits of these small animals. As they grow (between 10 and 20 years), meat of animals with stronger spirits is gradually added to their meals. Such animals may include monkeys, deer, turtles and larger birds. By 25 years, they graduate to the consumption of larger animals like elephant, panther and snakes. Very elderly men and menopausal women have the minimum or no food taboos because they have a long experience with all kinds of meat and also at that age their survival is no longer significant to society. Pregnant women have strict food restrictions among most of the West Malaysian tribes. Rats, squirrels, snails and small birds are mostly their only source of animal protein; animals believed to have weaker spirits. Rodents may be eaten by pregnant women if only caught by her husband and she must eat all of it alone. Husbands of pregnant women normally observe the same taboos as their wives, but once they give birth, their husbands are no longer tied to these taboos.

In Ghana, it is a taboo for the Gas and Ewes from Adaklu to eat snails. According to Gadegbeku, Wayo, Ackah–Badu, Nukpe, and Okai (2013), the consumption of ripe plantain is a taboo for Akan men but temporal taboo for pregnant women. Other food such as the pork, salted tilapia (koobi), banana, guava and coconut are taboo for pregnant women due to health considerations.

In Brazil, the Buzios islanders enforce food taboos as a measure to reduce the consumption of wildlife. Taboos may also be due the poisonous, harmful, aggressive and ugly nature of the species. Fish like the camburu is detested for its bad smell, aggression and ugly appearance. It is also known to be a source of measles, tumours and skin rashes. The carregado is tabooed because it causes inflammation to wounds.

Food taboos in Papua New Guinea are varied as a result of the multitude of cultures and people in the country. Food taboos are enforced as way of protecting humans from health hazards. Due to their recurring menstruation, women from the Onabasulu tribe are not allowed to eat juicy banana, fresh meat and all red-coloured foods. A menstruating woman must not eat an animal caught in a trap; if she does it is believed that future traps will fail. Mature woman must not eat fish and when pregnant, she is forbidden eggs. In contrast young unmarried men receive the best food and only obey the smallest number of taboos, but when married they no longer eat fresh, but only smoked meat. Not only women are the subject of food prohibitions. In the Kiriwina Island, men who intend going for shark fishing must abstain from sex and also fast and drink a large quantity of salt water. Species of fish like flat fish, stingrays are strictly forbidden during shark fishing. It is interesting to know that in some villages, chiefs are the only people who can violate certain taboos without any repercussion.

In 11 South American societies investigated by McDonald (1977), it is revealed that temporal food taboos exist for pregnant women, mothers of new born babies, boys, all children, menstruating women and fathers of new babies. Thus, among the Desana, pregnant women face a taboo for all meat for the whole period of pregnancy whereas pregnant women among the Waiwai are forbidden meat in the first two months of pregnancy. All fathers of new babies among the Kayapo do not eat monkey, anteater and coati, the first 14 days after the birth of the baby. Menstruating women from the Yanomamo and the Timbira tribes are prohibited from all meat for 60 days. Mothers of three-year-olds or less and adolescent females at first menses must not eat meat of any kind. Pregnant

women among the Kayapo and the Yanomamo groups avoid tapir and peccary. In other groups such as Siriono, all children are forbidden coati, anteater, night and howler monkey while parents of new babies are restricted from all meat among the Tenetehara and the Tukuna groups in the first 14 days. These food restrictions, to a very large extent, play significant role in wildlife conservation; they reduce the rate of meat consumption and time spent in hunting. As reported by Jimoh et al. (2012) some men would not go hunting for meat their children and wives are prohibited from consuming.

Finally, there is a great collection of religious taboos that restrict the killing, harvesting and consumption of certain animals and plants. These include Islam, which forbids pigs not only for religious reasons, but believers of Islam feel pigs are bred in revolting conditions and are not worthy of consumption. Practitioners of Hinduism prohibit the consumption of cows, as they are seen as gift from God to mankind. According to Meyer-Rochow (2009), those of the Brahmin caste of the Hindus do not handle meat, fish or eggs, let alone eat any of these foods. They also do not eat onions and garlic because these foods are believed to increase passions like anger and sex. Buddhists practise vegetarianism, thereby avoiding the consumption of any animal. Catholic Christians also enforce food taboos periodically in the pre-Easter weeks of lent, when meat must not be consumed. Judaism forbids aquatic organisms such as shrimps, lobsters and creatures that creep on the ground such as reptiles. All these prohibitions are geared towards promotion of health, protection of life and creating laws that unite people and bring group cohesion (Meyer-Rochow, 2009). It should be noted however that, whereas the majority of social taboos may be enforced to the detriment of a particular section of the population, religion-specific taboos have no specific target group; every member of the said religious sect must observe these prohibitions.

Species-specific taboos

The following category of taboos applies when a cultural group totally bans the killing and the detrimental use of specific species in both time and space (Colding & Folke, 2001). This group of taboos is often referred to as general or permanent taboos by anthropologists, because they usually apply to all members of the community and often concern food (Rea, 1981). Species, however, may be avoided not only for dietary reasons, but for a variety of other plausible reasons (Colding & Folke, 1997). These reasons may include species being considered as unclean (Bolton, 1972), inedible, poisonous or toxic (Begossi, 1992; Bolton, 1972), serving a religious purpose (Fargey, 1992; Sinha, 1995), the species having a legendary background (Ogbeide, 1974) or representing a reincarnated person (Osemeobo, 1994). Some species are also taboo as a result of their bad smell, aggressive and ugly appearance and their human attributes (Begossi, 1992). For example, the woolly lemur is forbidden in some parts of Madagascar as people believe it is an ancestor in animal form. Carnivores such as red-bellied lemur are strictly detested with the belief that they scavenge on their dead ancestors. In central and northeastern Madagascar, a number of species such as hedgehog tenrec, lowland streaked tenrec and crested drongo are forbidden because it is believed that such animals protected their ancestors from enemies during dangers like war. Many people also attribute the bubonic plague to the hedgehog tenrec; it is known to be an efficient reservoir of the disease, hence its prohibition. Moreover, as a result of the broad evidence that primates and bats have a high

zoonotic disease risk, majority of people taboo lemurs, a type of primate and bats. Marine species such as turtles, eels, sharks and some salt water fish which are food taboos have been found to possess toxins. In the Oban sector, Nigeria, the leopard is regarded as a symbol of a deity of *Ejagham* and therefore not hunted for food.

Certain plant and animal species are revered and accorded strict protection by communities and may not be touched, destroyed or eaten (Ntiamoa-Baidu, 2008). This tradition is very common among many ethnic groups in Ghana. Thus, in Boabeng-Fiema, Ghana, there is a local hunting taboo on two species of primates, the ursine black and white colobus and the Campbell's monkey. Any hunter or person who goes contrary to this norm faces severe spiritual retribution which could be sickness, madness or sudden death. It is believed that the existence of the villages depends on the monkeys. Thus the hunting ban or taboo preserves the health of the monkeys which in turn preserves the health of the village. As also reported by Baker et al. (2014), in southeastern Nigeria the sclater's monkeys are protected because they are considered the property of the deities; the monkeys are closely related to the people and there are adverse consequences for people who intentionally kill monkeys. These consequences could range from performing burial ceremony for the monkey, banishing the killer of the monkey, issuing monetary fines, being beaten by community members to supernatural or spiritual repercussions such as illness, madness or death.

In the Sariska region, India, to cut the peepal and banyan trees for any purpose is a highly divine offence. It is believed that the spirits of the ancestors reside in these trees. Some villagers believe as well that these trees represent the tie between the world of the living and the world of the dead, and therefore a link between the physical and metaphysical dimensions. The tiger is one of the most respected of species in the Sariska region and a good number of rural areas in India, so it is strictly forbidden to kill it. The belief is that the fierce goddess *Dugha* who represents the struggle against darkness and chaos is often believed to be riding a tiger. The tiger is also considered the protector of the forest. The local communities in this region protect all other wild species as well because they accept that the presence of the big predators is useful from an ecological point of view because they constitute an element of control on the utilisation of the forest and prevent its depletion. So in spite of the attacks these big predators make on their livestock, the people have no hostility towards them.

Spatial/segment taboos

This group of taboos applies when a cultural group bans the utilisation of particular species for specific time periods for human individuals of a particular age, sex or social status (Colding & Folke, 2001). Seven studies investigated the effects of spatial or segment taboos on conservation and health. The studies also described other taboo types. Segment taboos frequently pertain to pregnant women, children, menstruating females and parents of newborns. Cultural perceptions, customs and superstitious beliefs of human health risks are frequently related to such taboos (Osemeobo, 1994). All the studies in this category reveal conservation as the main reason for the enforcement of such taboos. Cinner and Aswani (2007) reported that in Papua New Guinea, Vanuatu, Solomon Islands and Fiji there are examples of temporary reef closures before religious ceremonies to replenish supplies of fish and invertebrate species. In central Himalayas,

the lower castes, the Harijans, are forbidden entry into sacrosanct zones such as sacred forests and water bodies. Menstruating women irrespective of the caste are strongly forbidden from entering sacred zones, especially rivers. This is a similar taboo to menstruating women in Talensi, Ghana, who are forbidden from entering sacred groves. Such temporal restrictions could play a significant role in resource conservation within the duration of the menstrual cycle. In Madagascar, Jones et al. (2008) report that during pregnancy women do not eat a species of pandan and eels because it will cause miscarriage or they will have multiple births. Further, in the Oban hill sector, Nigeria, both men and women are restricted from entering certain sacred areas on particular days. Other forest reserves such as *Mgbe* forests are forbidden to anyone who is not initiated into the cult which helps to regulate the forest resources' extraction. As Kajembe et al. (2003) clearly observe, such restrictions on the use of certain plants, animals or areas prevent the over-utilisation and depletion of natural resources.

Temporal taboos

According to Colding and Folke (2001), this category of taboos applies when a cultural group bans access to resources during certain time periods. Taboos may be imposed sporadically, daily or on a weekly to seasonal basis. Most traditional societies enforce taboos on both aquatic and terrestrial resources. Some communities may impose taboos on certain plants until they are fully mature for harvest. In this review, six studies discuss temporal taboos. Colding and Folke (2001) mention that sporadic taboos exist among clans of Tikopia, Solomon Islands, which impose them on particular totemic food stuffs, such as yam, taro, breadfruit and coconut. A chief may impose a closed season on food resources by a simple declaration at a public meeting, which can last several weeks or months. It is also reported that, in Samoa, chiefs could impose sporadic taboos in times of severe drought and after cyclones on food resources and even temporarily impose restrictions to habitats in need of recovery. In Uttarakhand, central Himalayas, India, as in the rest of the country, many castes abstain totally from consumption of fish, poultry and meat, and suspend all hunting as well, during the Hindu month of "Sravana", roughly August (Negi, 2010). In Madagascar, any species of the pandan cannot be brought into the village while there is still rice growing in the field (Jones et al., 2008).

Life-history taboos

These taboos forbid the use of species at certain vulnerable stages of its life based on age, size, sex and reproductive status. Three studies examined the effects of this set of taboos on conservation and health. For instance, in Behoavaro, Central Madagascar, tail-less tenrec should not be harvested until after they have reproduced, before hibernation in April/May (Jones et al., 2008). Negi (2010) reveals that, in India, hunters will usually let lose any animal suspected to be pregnant or having a young one. An example is the institution of *Mrigoli* where hunters do not hunt a pregnant doe when they are in a flock. Moreover, a hunter will not kill a deer with a white mark on its head as it is seen as a reincarnated departed member of the community. All these are strategic measures enforced by the communities at ensuring the continued growth of the wildlife population.

Gear/method taboos

Method taboos are a set of taboos which forbid the use of certain methods or techniques for the withdrawal or exploitation of species. Certain gear types and methods are banned by taboos, especially those that easily may deplete or drastically reduce the stock of a resource. There are three studies in our review which discuss method and gear taboos. These taboos range from the use of fishing-related method taboos to hunting method taboos such as the use of gill nets; spear guns, light torches, toxins and chemicals, draw nets, mesh and others. Such techniques or methods are considered taboos because of their effective and most exploitative nature. Others are also banned due their destructive potential on the resource habitats. Thus, according to Jimoh et al. (2012) the *Chans* in the Oban sector, Nigeria, have traditional laws prohibiting the use of poisonous herbs and chemicals in the harvesting of fish from streams and rivers. Violators are made to pay a heavy fine to the community.

In Bevoahazo, central Madagascar, fishing nets are not used in harvesting fish from the main river in the community. Similarly, at the Sakumono lagoon in Ghana, there is a taboo on the use of draw nets and mesh whereas inhabitants of the Djange lagoon also in Ghana observe a taboo on the use of poles and sticks for fishing (Ntiamoa-Baidu, 1991). Also in Maluku, Indonesia, community leaders use customary management to ban cyanide fishing. These gear or method taboos may serve the purpose of ensuring that everyone has equal access to the resources.

RHTs and human health in the context of global environmental change

Although it is well documented that human health is a function of ecosystem health, the review shows that emphasis on the linkage of ecosystem change, ecosystem services and specific human health outcomes is fairly recent (see Daszak, Cunningham, & Hyatt, 2000; Dobson et al., 2006; MEA, 2003). In this context, the linkage between resource habitats and human health have been conceptualised in four fundamental ways: quality of life, medicinal and genetic resources, constraints on infectious diseases and ecosystem services (Sala, Meyerson, & Parmesan, 2012).

Resource habitats play a fundamental role in the physical, mental and social well-being of populations globally. Despite significant improvements, major differences in the quality of resource habitats and human health remain between and within countries. The complex relationships between resource habitat factors and human health, taking into account multiple pathways and interactions, should be seen in a broader spatial, socio-economic and cultural context. The loss of resource habitats, via air pollution, noise, chemicals, poor-quality water and loss of natural areas, combined with lifestyle changes, may be contributing to substantial increases in rates of obesity, diabetes, diseases of the cardiovascular and nervous systems and cancer – all of which are major public health problems for the world's population (see Levy et al., 2012). From Table 2, it is evident that a plethora of negative human health outcomes are associated with the erosion of RHTs. Climate change will likely exacerbate these adverse health effects. For instance, Myers and Patz argue that climate change, as indicated by warming temperatures, more extreme storms, hydrologic extremes, sea-level rise, acting in concert with land cover change, will probably culminate

Table 2. Specific health outcomes identified in the empirical studies.

Reference, year (Study design/methods)	Research approach	Specific ecological and human health outcomes
1. Saj et al. (2006) (Mixed methods)	Primatological and ecological study involving data on the ecology of the forest (structure and composition of the forest), the monkeys' use of their habitat (diet, ranging behaviour, etc.) and their social behaviour	Fertility rate (the proportion of immature individuals in the population and the ratio of immature individuals to adult females); Shannon-Wiener Index of Diversity; average tree size per quadrat; human or domestic animal defecation in the forest
2. Golden and Comaroff (2015b) (Cross-sectional; mixed methods)	Interviews with Malagasy male heads of households living adjacent to the Makira Natural Park	Zoonotic disease, allergies and toxins
3. Meyer-Rochow (2009) (Review)	Authors' own experience, observations, recordings and interactions with locals in communities	Nausea, vomiting, diarrhoea, cramps; sickness-causing parasites; high blood pressure, atherosclerosis, rheumatism, arthritis, boils, asthma and eczema; toxic ulcers of the legs
4. Ogbeide (1974) (Qualitative)	Population survey	Child jaundice, liver abscess, severe abdominal pains, delays in labour, physical stamina
5. Begossi (1992) (Quantitative)	Field observations, interviews	Neurotoxicity, body wounds, measles, tumours and skin rash; medicinal preservation
6. Santos-Torres and Vásquez-Garibay (2003) (Cross-sectional; qualitative)	Observational study using questionnaire and a 24-hour dietary recall	Infantile colic or diarrhoea; dehydration; maternal and child nutritional status
7. Jimoh et al. (2012)	Reconnaissance survey, structured survey questionnaire, key informant interviews, stakeholder meetings	General health
8. Bolton (1972)	Population survey	Amoebic dysentery, chronic disease
9. Gadegbeku et al. (2013) (Cross-sectional; qualitative)	Structure questionnaire, purposive sampling	Maternal and child obesity, nutrition

in the erosion of resource habitats and the ecosystem services they provide. This, in turn, will negatively influence human health. This view is supported by Levy et al. (2012).

Discussion

Generally, a social taboo prohibits an individual or group from doing something such as touching a sacred person, killing a certain animal, eating certain food, eating at certain times, entering a particular place and many others. They constitute unwritten rules that regulate human behaviour (Meyer-Rochow, 2009) and may be enforced for several reasons. According to Barfield (1997) there may be as many as 300 reasons for particular avoidances.

This review revealed several RHTs observed in different parts of the world. The analysis further identified human health and conservation as some of the major reasons for the adherence of certain taboos, especially food. On food avoidances and preferences, our survey of the literature showed that food intake, especially proteins by children, pregnant and lactating women, has been severely affected by taboos. There are strong restrictive measures on protein intake affecting them. Whereas the majority of these taboos affect children and women, men have the fewest taboos to observe. While in some areas women observe permanent restrictions on the consumption of a particular food, men

may have only temporal or no restrictions at all. One can therefore view this as a clear picture of societies in which taboos are enforced to the detriment of children and women and to the benefit or best interest of men. These restrictions on food consumption (e.g. eggs, meat by children and pregnant women) have severe consequences on their health-negative nutritional outcomes. Even though it may be plausible to understand that certain foods are avoided as a result of their potential health risks or a strategic measure at conserving the food resource, it is unclear and perhaps unscientific to impose restrictions on the consumption of foods with vital nutritional content.

The study also found other sets of taboos, which forbid the exploitation of specific animal or plant species. Such prohibitions are usually observed by an entire community (Rea, 1981) for a variety of genuine reasons (Colding & Folke, 1997) ranging from the species having harmful effects; the species being unclean, inedible, poisonous or toxic; the species having ugly appearance or aggressive behaviour to the species being considered an ancestor or having special relationship with members of the community. Restrictions on the use of certain technologies for species withdrawal or harvest have also been reported as one of the measures at conservation and ensuring equity on resource access and harvest and maintaining employment (Colding & Folke, 2001). Also, local laws against the killing or harvesting of animals and plant species during their reproductive or any other vulnerable stage contribute to the continued growth of wildlife populations. Taboos which restrict access to the utilisation of a resource on certain days and those that forbid particular members of the population from the use of a resource, in a number of ways, help to conserve resources.

Overall, taboos as traditional conservation practices are common in many parts of the world, particularly Africa and Asia. They have been seen to ensure social order in many local communities. However as much as taboos contribute to ensuring conservation and human health, it is very important to understand that their strict adherence equally has adverse consequences on some sections of the population. Apart of from taboos that are associated with the major religions of the world, a great number of other social taboos appear to be discriminatory against some members of the population, especially children and women. It is important to note that as result of globalisation, migration, Western education and other new developments certain taboos will most likely lose their strict adherence.

It is also very important to note that climate change can have direct and indirect effects on species and resource habitats including protected areas (Leader-Williams et al., 2010). These effects comprise increase in ocean temperatures, increased spread of wildlife diseases, the supply of nutrients and direct loss of habitat due to sea-level rise, increased fire frequency and altered weather patterns (FAO, 2015; Mawdsley, O'Malley, & Ojima, 2009). Predictions regarding the effects of climate change on resource habitats vary. Some scientists (e.g. Price, Qvarnström, & Irwin, 2003) suggest that many tree populations have sufficient phenotypic plasticity (the ability of an organism to change its phenotype in response to changes in the environment without genetic change) and genetic diversity to enable them to adapt reasonably well to the effects of climate change. Others envisage significant problems (e.g. FAO, 2015). The data currently available suggest that climate change will affect resource habitats via many different demographic, physiological and genetic processes. Extreme climatic events that kill large numbers of trees may become more common. More gradual changes in temperature and precipitation may inhibit the

capacity of forests to regenerate. In some places, pest and disease attack may become more severe because climatic conditions become more favourable for the attacking species or because climate-induced stress makes trees more susceptible to attack (FAO, 2015). Climate change may break the synchronism between trees' flowering periods and the active periods of pollinator species (FAO, 2015). A decline in the availability of pollinators limits gene flow and reduces the effective size of tree populations and therefore impedes their capacity to adapt to climate change. Overall, these changes tend to militate against the distribution, abundance, the mating and reproduction cycles of animals, plants and other marine life (FAO, 2015). For instance, higher temperatures could force species to migrate to areas where temperatures are more conducive to their survival. Other climatic events such as increase in sea levels and intrusion of saltwater into fresh water could force some marine species to relocate, reduce their reproduction level or die. The shortage or loss of these species certainly will affect taboos that regulate these resources and their habitats or protected areas and also affect the exploitation or harvest of species for medicinal purposes or as food. This is because due to climatic changes; it is very possible that these habitats or protected areas may no longer hold the species or resources for which they were originally designated (Leader-Williams et al, 2010).

According to the FAO (2015), catastrophic extreme weather events such as floods and droughts, which in many parts of the world are expected to become more frequent because of climate change, can pose an immediate threat to the survival of plant and animal resources that are raised only in specific small geographical areas. In the event that a particular species of plant or animal relocates or completely dies as a result of climate change, the recognition and adherence of taboos protecting or regulating the harvest or exploitation of such plants or animals will serve no practical significance. The imposition or enforcement of taboos may be irrelevant as there will be no resource to protect and this may not influence in any way how the harvesting or exploitation methods of these species are regulated. In essence, as there is reduction or shortage or even complete loss of a species due to climate change, there will be nothing to impose restrictions on. It is even possible that, in some communities, most people will not embark on hunting or fishing at certain times of the year due the loss or relocation of specific species. In such instances, this source of livelihood may be irreversibly lost.

Conclusion

Long before the existence of central governments, local communities were governing their resource use through customary regulations. One of the main governance mechanisms in customary practices are social taboos such as RHTs. RHTs are not exclusively rooted in ecological values, but can also emanate from social or religious values. The current systematic review focused on the linkages between RHTs and human health, basically due to the appreciation that, in the context of climate change, erosion of social taboos may potentially culminate in the loss of natural resources of medicinal value. We identified 779 studies and data from four academic databases. Twenty-six studies were eligible for the analysis. The duration of empirical studies ranged between three weeks and seven years and only nine studies explicitly linked RHTs to human health. Overall, nine social taboos, namely spatial, temporal, gear, method, effort, catch, species-specific, life history and segment, were addressed by the empirical studies. Several human health outcomes

associated with RHTs were identified in the review. These include amoebic dysentery, chronic disease, maternal and child obesity, infantile colic or diarrhoea, neurotoxicity, body wounds, measles, tumours and skin rash. Others include child jaundice, liver abscess, severe abdominal pains, delays in labour, physical stamina, nausea, vomiting, diarrhoea, cramps; sickness-causing parasites; high blood pressure, atherosclerosis, rheumatism, arthritis, boils, asthma and eczema; and toxic ulcers of the legs. However, the interpretation of the association regarding causal inference of RH loss and adverse human health outcomes is limited by lack of clear observed effect size, lack of sufficient studies and methodological limitations. The systematic review concludes that RHTs may have positive or negative health effects on certain categories of people depending on the demographic, social, behavioural, cultural or genetic context. To a large extent, the context also determines the vulnerability of a particular category of people to environmental change-induced loss of resource habitats. Adequate adaptation to the deleterious effects of environmental change, in local communities particularly in kincentric societies, can benefit from policies that emphasise the various ways in which resource habitat management may impact human health on a long-term basis.

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ORCiD

Frederick Ato Armah http://orcid.org/0000-0002-9371-5683
Isaac Luginaah http://orcid.org/0000-0001-7858-3048

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