ISSN 2731-7890 (Online)

International Journal of UNESCO Biosphere Reserves

www.biospherejournal.org

Published by VIU Press

Volume 2 Issue 2 November 2018

Learning by example: A historical account of the experiences and transformation in the management of the Mount Arrowsmith Biosphere Region (Reserve), Vancouver Island, Canada.

Glen Jamieson[1] and Karen Hunter[2]

[1] 804 San Malo Cr., Parksville, BC, V9P 1S4 Canada
[2] Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC, V9T 6N7 Canada

Abstract

This report outlines the developmental history of the MABR from its conception in the early 1990s through its evolution into an effective, functional biosphere region in 2016. It describes why and how the biosphere reserve concept was initially felt to be appropriate for the region; the challenges in trying to achieve UNESCO recognition without initial senior (provincial and federal) governmental support, and how this lack of support was overcome; the initiatives undertaken in the first decade after establishment; and how the biosphere reserve almost collapsed when it was largely commandeered by community members that had an anti-development advocacy agenda. It concludes by describing how the initiative evolved into what is now one of the most productive and dynamic Canadian biosphere reserves. The documented experiences of the world's biosphere reserves are valuable educational products, and it is hoped that descriptions of the challenges encountered and overcome in the Mount Arrowsmith Biosphere Region (Reserve) can benefit the development of other biosphere reserves both in Canada and world wide.

Introduction

The United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and the Biosphere Programme (MAB) created the concept of biosphere reserves to recognise areas where local citizens are attempting to achieve a balanced relationship between people and nature to ensure environmental, economic and social (including cultural and spiritual) sustainability. This is achieved by striking a balance between the goals of conserving biological diversity, promoting economic development, and maintaining associated cultural values. A biosphere reserve demonstrates practical approaches in addressing its unique challenges in balancing conservation and local human use in its area.

The Biosphere Reserve World Network is more than a listing; biosphere reserves exchange knowledge and experiences on sustainable development innovations across national and continental borders. Of the more than 669 biosphere reserves in 120 countries now designated by UNESCO MAB in 2016 (Fig. 1), each has a unique story and history.[1] Benefits gained from being part of the network include access to a shared base of knowledge and scientific research, working toward high-level and common goals, and the opportunity to connect internationally to other biosphere reserves on issues of conservation, development, and sustainably managed ecosystems. The biosphere reserve concept is applied differently within each local context, and even among biosphere reserves in one country such as Canada, there are a multitude of ways that local communities embrace the opportunity that a designation offers (e.g., Canadian Biosphere Reserves (2012)). Biosphere reserves are areas that explore innovative approaches in a vast diversity of policy and management fields to work towards achieving a balanced

[1] The number of biosphere reserves worldwide is as of May 2018 (www.unesco.org/new/en/natural-sciences/environment/ecological.../biosphere-reserves/)

relationship between mankind and nature as defined in Biosphere Reserve policy and strategy documents (Seville Strategy (1996), Madrid Action Plan (2008-2013)). In order for an area to be included in the World Network of Biosphere Reserves, work towards these ends within the area must be initiated at the local level, appropriate information about the region must be summarised, and the local population needs to have expressed its written support. Nominations for a biosphere reserve are prepared and submitted to UNESCO by national governments, in most cases through MAB national committees.

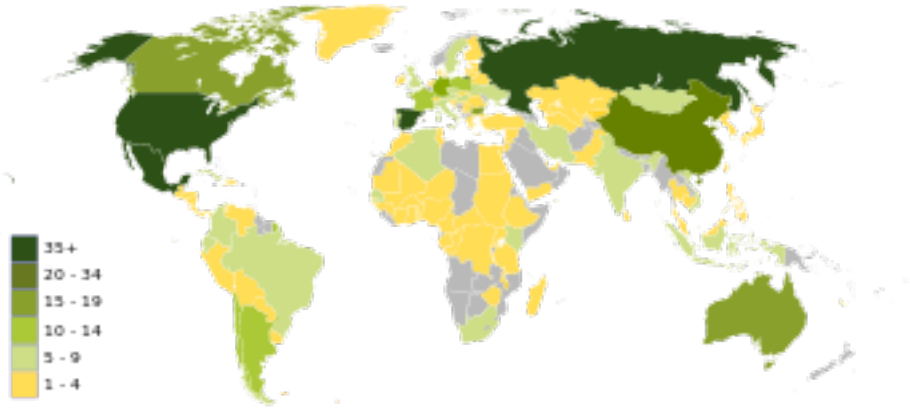


Figure 1: Map showing the World Network of Biosphere Reserves. As of 2016 total membership has reached 669 biosphere reserves, including 12 transboundary sites, in 120 countries occurring in all regions of the world.

This document summarises the development history of one of the earlier community-initiated biosphere reserves in Canada, that of Mount Arrowsmith, in the hope that descriptions of the challenges overcome there can benefit the development of other biosphere reserves both in Canada and world-wide.

The Canadian Context

Biosphere reserves were established in Canada (Fig. 2) in two general episodes: an early federal government-initiated creation of six biosphere reserves (1978 to 1990) and a later more community-driven establishment from 2000 to present day. There are now 18 biosphere reserves (BRs) in Canada, with the most recent, Beaver Hills BR in Alberta and Tsá Tué BR in the Northwest Territories, designated in 2016.

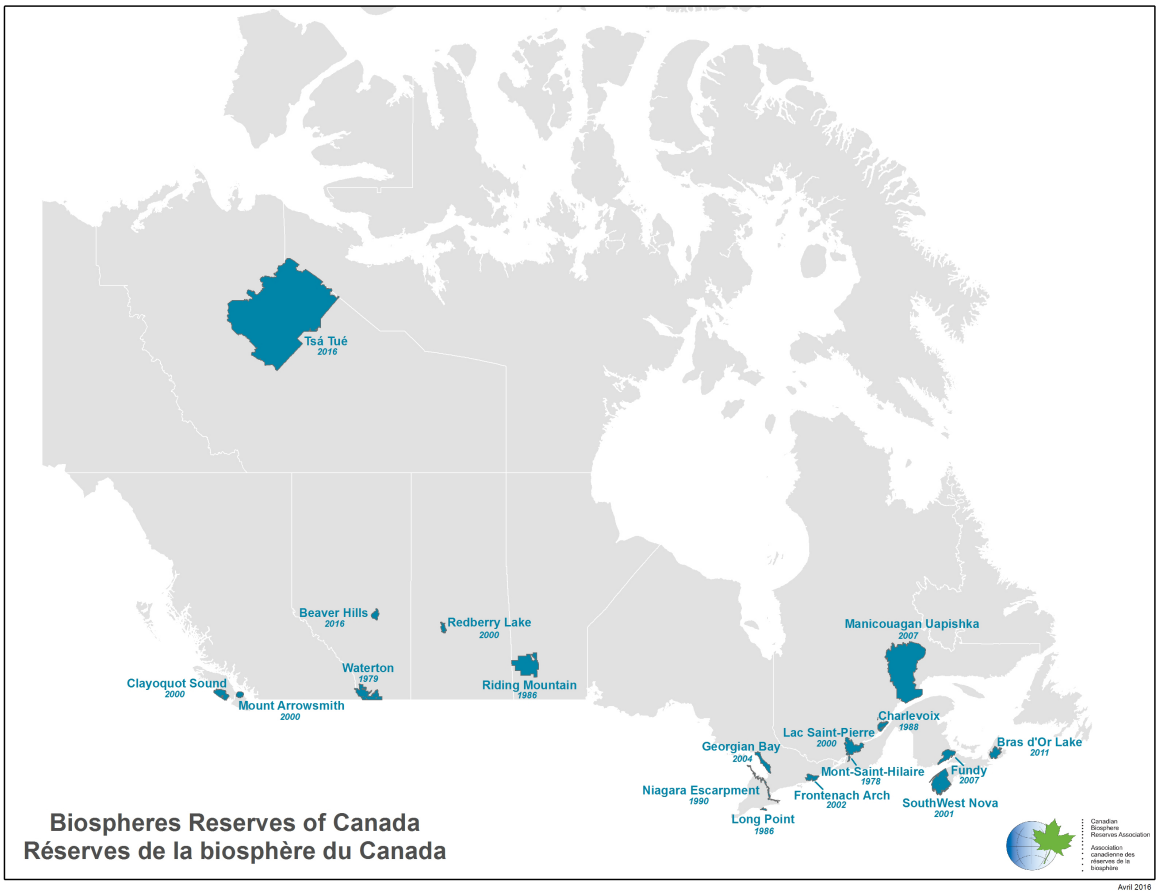


Fig. 2. Canadian biosphere reserves in 2016. Mount Arrowsmith is second from the left.

Biosphere Reserves in Canada – prior to 2000

Canada's first biosphere reserve, Mont Saint-Hilaire, was established in Quebec in 1978, followed by Waterton in Alberta in 1979. Between 1986 and 1990, four more were established – one in Quebec (Charlevoix), two in Ontario (Niagara Escarpment and Long

Point), and one in Manitoba (Riding Mountain), creating a Canadian network of six biosphere reserves. In keeping with early days and development of the MAB Programme, these biosphere reserves were all established by the federal government with little involvement or formal coordination by local people.

Development of the MABR Proposal

In the late 1980s and early 1990s, public interest in the well-being of the environment in British Columbia (BC) increased dramatically: the logging of old growth forests in coastal BC was of particular concern, along with concerns about sprawling residential development and the scale and nature of resource extraction activities occurring in many west coast communities, including fishing. This increase in human environmental impacts in BC coincided with the new awareness in BC of the potential of biosphere reserves, which until then had not been regionally talked about. In the early 1990s in the area of the future MABR, a group of local citizens were organizing regional and local environmental committees to try and conserve local environmentally sensitive areas that were being threatened by residential development, including the Englishman River estuary in Parksville on the east side of Vancouver Island. The Society for the Preservation of the Englishman River Estuary (SPERE) was formed, and along with other local groups, pressure (including national news coverage) was exerted on governments to protect this area, resulting in the establishment of the provincial Parksville/Qualicum Wildlife Management Area (PQWMA) in 1992. However, Dr. Glen Jamieson, then president of SPERE, soon realized that while the Englishman River estuary area was now protected, a functional estuary only existed if the river's water flow rate and quality were also being adequately monitored and managed, which was not then the case. For example, in the winter, when rains were heavy and the river had its maximum flow rates, turbidity was high, so cleaner water from regional wells was the preferred municipal water source and impacts on the river were minimal. However, in drought periods in the

summer, river flow rate often decreased to less than one m^3/sec, yet this was the time of year when river water use by local governments was high due to the river's summer low turbidity. Coupled with a greater summer municipal water demand from a growing residential community, gardening, increasing tourism and increasing pollution from agricultural runoff upstream, the "health" of the river for aquatic species was increasingly a concern of SPERE. Protection of the estuary alone was seen as not sufficient, and sustainable water management needed to include the entire watershed.

In 1993, environmental groups around the Strait of Georgia were brought together by the Georgia Strait Alliance, formed in 1990. The concept of "biosphere reserves" was raised at one of the early information meetings, and Dr. Jamieson realised that this concept might be particularly appropriate for the east side of Vancouver Island. This area in the Georgia Basin had both unique ecosystems and unique resource management challenges, as it was almost entirely privately owned and the most urbanised area in BC. While biosphere reserve designation in itself did not legislatively protect land, it would further encourage awareness and responsibility by local peoples to take actions that would conserve values that they alone identified as important to them.

Emphasis was placed on the biosphere reserve's non-advocacy role and their potential to be living examples of how research and education relating to specific local challenges could lead to improved local sustainable management. It was this new awareness of the biosphere reserve concept that resulted in an effort to establish a biosphere reserve in the British Columbian Georgian Basin, and specifically in the Englishman River watershed, which led to the proposal of the MABR. However, despite the local importance of the Englishman River Estuary, its extent (about one square kilometre in area) was relatively small compared to the areas of other Canadian BRs, and did not include any legislated core protected areas which often formed the basis of a BR given UNESCO guidelines of

the day (Seville Strategy 1996). To ensure that riverine flow rates and water quality issues could be managed as sustainably as possible over a more extensive area of adjacent watersheds, the desired boundaries of the MABR were established as the entire watersheds of the rivers and creeks flowing into the Strait of Georgia from Lantzville to the southeast and Bowser to the northwest (a straight line distance of about 30 km, although the actual shoreline distance is about twice that). These were the Englishman, Cameron and Little Qualicum River watersheds, the Nanoose and Bonell Creek watersheds, and the smaller stream watersheds between them. Five relatively small Provincial Parks within these watersheds then met UNESCO's definition of core areas within the BR.

Based on his involvement with local stewardship groups, and the termination of SPERE after the establishment of the PQWMA in 1993, Dr. Jamieson prepared a prospectus for a Mount Arrowsmith Biosphere Reserve (MABR) that he presented to municipal governments. At the same time, he engaged the Canadian Commission for UNESCO (CCU) and representatives from the six established biosphere reserves in Canada (four were affiliated with a National Park) in an effort to find out how to establish a new biosphere reserve. Representatives from the other Canadian biosphere reserves and Parks Canada provided encouraging support. During the mid-1990s, the UNESCO designation process advanced to incorporate recommendations of the Seville Strategy (1996), which required evidence of bottom-up community interest in the concept, including municipal and provincial support in the Canadian context.

While at the time there were no official steps or directives on how to proceed, it was suggested by a representative from the CCU that to achieve a Biosphere Reserve designation, an area would have to be functioning as a biosphere reserve before applying for the designation. It was noted that evidence for this would include the provision of

regionally relevant research in support of achieving sustainability. Dr. Jamieson, as a federal research scientist, took on the scientific/educational aspects of UNESCO's directives for biosphere reserves and initiated a program of regionally relevant research in support of achieving sustainability. By 1996, the first specific MABR research initiatives were underway, including a study with the Canadian Wildlife Service of Arctic-bound migrating Brant (a marine goose) which rely on seasonally productive waters for foraging each spring in the proposed biosphere area; an analysis of riverine/forest connectivity in the local area (the biodiversity and abundance of insects was monitored over streams and into the adjacent forest); and other initiatives supporting long-term research and monitoring such as the establishment of a Smithsonian Forest Monitoring Plot in the Mount Arrowsmith watershed.

With the cooperation of community members, the Mount Arrowsmith Biosphere Foundation (MABF) was registered in 1996 as a non-profit society, which was intended to be the management committee for a biosphere reserve in the area, if and when it was to be formally recognized. Based on the British Columbia Society Act (1996), the society was managed by a group of elected Directors who held decision-making and fiduciary responsibilities of the society as outlined in a formal MABF operating framework. Regional municipal representatives participated as liaisons, not as directors, to avoid any perceived conflict of interest. A seat on the Board was allocated to each of the two local Salish Sea First Nations (the Snaw-Naw-As in Nanoose Bay and the Qualicum further north), the two international timber companies that owned most of the proposed biosphere reserve's land, along with open chairs for community representatives. Thus, while there are seven First Nations with territories that the BR overlaps (see below), seats were only offered to the above two, since the others only had minor territory overlaps. The MABF provided a basic structure for activities, gave the initiative credibility, and to ensure as much community participation as possible, membership in the society was not

restricted beyond paying for an annual $5 membership. However, as will be shown, in addition to resourcing the MABF (human and financial), this latter decision caused serious problems in the evolution of this biosphere reserve.

As the MABR concept was emerging on eastern Vancouver Island, representatives from the six existing Canadian biosphere reserves formed the Canadian Biosphere Reserves Association (CBRA), with the future MABR participating as an associate partner. The CBRA aimed to improve collaboration among Canada's existing biosphere reserves and to advocate for federal support on behalf of all Canadian biosphere reserves. Circa 1996, there was no directed federal financial support for any Canadian biosphere reserve, but those reserves that included a national park received logistical support and minimal funding ($5000 year) from Parks Canada for associated activities. Incorporated in 1997, annual CBRA meetings were held, many in association with the "The Leading Edge" conference series jointly organized by the Niagara Escarpment and Long Point BRs near Hamilton, Ontario. Dr. Jamieson presented a number of papers (Jamieson 1997a,b) at these meetings, documenting his efforts in BC to establish the Mount Arrowsmith Biosphere Reserve, and in 1998, he was encouraged to gather and submit the information required for a formal application to the Canada Man and Biosphere Committee (Canada MAB) to make this a reality. With assistance from two MABF members and Dr. Fred Roots, then Chair of Canada MAB, the application was in its final stages by late 1999. No financial or planning support was directed toward the project from potential funding agencies. However, the nomination process came to a sudden halt in 2000 when the BC government indicated it would not support the MABR application.

This lack of support centred around perceived conflict with another BC biosphere reserve initiative underway at the same time, which was receiving significant financial support from both the BC and federal governments. Together, these governments hired a

consultant to prepare a submission for a proposed Clayoquot Sound Biosphere Reserve on the west coast of Vancouver Island. This initiative arose from Jean Chrétien's interest as Canada's Environment Minister in 1993 to address and resolve the dispute over old growth logging in that area that received international attention, in part due to the largest mass arrests for civil disobedience in Canadian history. In 1996, as Prime Minister, Chrétien decided that the creation of a biosphere reserve in and surrounding Clayoquot Sound would make a strong environmental statement in support of sustainability. Work was initiated to gain local support from communities, First Nations, and local business groups (logging, fishing, and aquaculture). While the two initiatives were unrelated, Dr. Jamieson and Ross McMillan, the consultant that was leading the process to establish the Clayoquot Sound BR, were in close contact and the two initiatives, one on the east side and the other on the west side of Vancouver Island, happened to come to fruition at the same time. At that time, feedback to the MABF from the province indicated that the MABR application should be temporarily withdrawn, as representatives from both the province and Canada wanted the Clayoquot Sound application to be considered by Canada MAB alone to give it maximum profile. The understanding communicated to Dr. Jamieson was that the BC government would then support the Mount Arrowsmith submission in the next UNESCO consideration period of proposed new BRs.

In the Clayoquot Sound area on the west side of Vancouver Island, all forestry land was Crown Land, and as such, government had an influence on how it would be managed and ultimately logged. Governments were thus able to apply pressure to obtain consensus from all the main interests in the Clayoquot Sound area to support designation of the Clayoquot Sound BR. In contrast, because of the 1884 Esquimalt and Nanaimo (E&N) land grant on southeastern Vancouver Island between government and the logging industry, by the late 20th century, virtually all forestry lands in the Mount Arrowsmith area (i.e., most of the proposed biosphere reserve area) were owned by private

international forestry companies and much of the remaining land base was also held by individuals under private ownership. Supporting an initiative that would place a UN designation on privately owned lands was a difficult request for international forestry companies to support, and these private entities could not be entreated to support the Mount Arrowsmith BR designation. Executives of the forest companies in the proposed MABR thus approached the province and said that since consensus for a BR was required by all the major interests in the Clayoquot Sound area, it should also be required in the Mount Arrowsmith area, which caused the province to back off on its earlier indication of support for the Mount Arrowsmith BR nomination. A provincial representative even suggested to Dr. Jamieson that all private forestry land should be removed from the proposed MABR boundary, which Dr. Jamieson refused to consider since it was not compatible with achieving desirable overall watershed management practices, which was the rationale for trying to obtain MABR designation in the first place.

In contrast, local communities and First Nations in the proposed MABR were receptive to the biosphere reserve concept and potential future opportunities it might invite, such as increased local environmental awareness and tourism to a "model area", and provided written support for the nomination. In these early stages, none of the local First Nations that were engaged expressed concern about a biosphere reserve designation despite their unresolved territorial rights and claims associated with the proposed boundary.

Despite the lack of support from the province and the lack of clarity in the requirements to proceed with an application at the time, Dr. Jamieson nevertheless elected to proceed. Further research into the UNESCO nomination process revealed only two requirements actually existed at that time: 1) that proposed biosphere core zones (areas with legislative protection) would stay protected into the foreseeable future, and 2) that industry management policies were of a sustainable nature. There was no actual mention of a need

for formal written support from the higher levels of either government or industry. Dr. Jamieson then confirmed in writing from local protected area managers that the existing parklands would remain protected into the foreseeable future. Policy documents from the local forestry companies were also found on the internet and were included in the BR application to document that industry management policies indicated that the forest companies wanted to work with local communities in support of sustainable forest management. Dr. Jamieson submitted this collection of material as required in the nomination process for the MABR to the Chair of Canada MAB, where it was accepted and then sent to UNESCO in the spring of 2000. The nomination was also accepted that spring and due to a delay in Paris in the approval of earlier submitted nominations that included the Clayoquot Sound BR, formal recognition of both the Clayoquot Sound and Mount Arrowsmith Biosphere Reserves ultimately did occur unexpectedly together in November 2000.

The designation of the Mount Arrowsmith Biosphere Reserve was not expected by either the Province of BC or the forestry companies, and their concerns were expressed to both the Canadian Commission to UNESCO (CCU) and to UNESCO headquarters. However, UNESCO determined that all relevant criteria had been considered, and so recognition of the Mount Arrowsmith Biosphere Reserve remained. Provincial representatives then stated that while the "birth" of the BR was "irregular," the "baby" had nevertheless been born, and so it would be recognised by governments. At a public dedication ceremony of recognition by UNESCO six months after the designation, provincial representatives participated and even announced a significant expansion in area of one of the provincial protected BR core areas, the Parksville-Qualicum Wildlife Management Area. However, while the Clayoquot Sound BR received a $12 million endowment fund (the Clayoquot Biosphere Trust) from Canada for its operations, Mount Arrowsmith did not receive any start-up or operational funding from either the province or Canada, and to this date, along

with most other biosphere reserves in Canada, fundraising still remains a priority activity for the MABR.

Mount Arrowsmith Biosphere Reserve - 2000 to 2009

The Mount Arrowsmith Biosphere Reserve (MABR) is located on the east coast of Vancouver Island, British Columbia. From the top of Mount Arrowsmith (1817 m) in the Beaufort Mountain range, the MABR extends down to the sea, where it includes islands in the Ballenas/Winchelsea Archipelago and a marine area extending halfway to Lasqueti Island to a depth of about 300 m below sea level. The total land area is approximately 800 km^2 and the marine area at the surface is about 400 km^2.

The BR is primarily within the Traditional Territories of the Snaw-Naw-As First Nation and Qualicum First Nation on the east side of Vancouver Island, but also overlaps portions of the unceded territories of the Snuneymuxw, K'omoks, Tseshaht, Hupacasath, and Ditidaht First Nations on the western side of Vancouver Island. Local governments include the City of Parksville, Town of Qualicum Beach, and the Regional District of Nanaimo (RDN). These governments and institutions are joined by dozens of registered non-profit organizations that address local MABF concerns, such as stream habitat enhancement and migrating seabird monitoring. Along with these groups, an active citizenry that is known for volunteerism and involvement in local issues characterizes the mid-Island area.

While it had been established early on that there was little in the way of formal guidelines for achieving the biosphere designation at the time, the MABF also found that the path for both achieving the high level mandate of BRs and to make it relevant at the "boots on the ground" level was also not clear, with the result that society membership remained

small. In the early years following the MABR's designation, the society even struggled with maintaining a full slate of volunteer directors for the MABF's eight-member Board of Directors (BOD). Part of the reason was that functional BRs often have funded support staff to achieve MAB goals. In the absence of funds and with few society members because of the challenge described above, the MABF had a reduced capacity to work towards realizing the potential benefits outlined in the MAB Programme. The reality was that 1) there was a very limited number of highly dedicated people involved, and 2) a lack of funding. A small group can do a lot, but dedicated time and effort is needed, which is difficult when funding is not available. In this situation, a small group might not accomplish as much in the same time as a larger one, although more could have potentially been accomplished with a different group of people. Under these circumstances, the MABR could have benefited had it had more capacity to support staff to work towards the goals the MAB Programme laid out (Seville Strategy 1996; Madrid Action Plan 2008-2013). In contrast, funding was not a problem with the nearby Clayoquot Sound BR, which could utilise funds earned by their large endowment. Thus, whereas the focus of the MABF quickly turned to fund-raising, the focus of its sister biosphere reserve was focused on how best to allocate its available resources.

However, difficulty in obtaining operating funding did not impede all progress in the early years - some limited, project-specific funding was obtained for research, including:
1) the continued monitoring of the Smithsonian Biodiversity plot located in one of the MABR's core protected areas (with student and volunteer labour),
2) initial GPS documentation of invasive plants and animals locations in some of the core areas with federal-funded summer student support,
3) establishment of a GLORIA (Global Observation Research Initiative in Alpine Environments) site on the top of Mount Arrowsmith to document the effects of climate on alpine flora through involvement of a local university graduate student,

4) documentation of tagged migrating Brant geese for the Canadian Wildlife Service by a seasonal contract, and
5) development of a two-part television series titled "Liquid Assets", which was about the Importance of water, i.e., its source and its usage, in the MABR, which was shown repeatedly on local television stations.
All this funding was secured by Dr. Jamieson through his professional contacts and his associate professor status with local universities, and he was the administrative supervisor in all these initiatives. While biological research was being conducted, initiatives in social sciences focused towards increasing community engagement were lacking. Volunteer effort within the BOD in this capacity was not present, but Dr. Jamieson did manage to get some support to document the environmental education challenges the initiative was experiencing (Fraser and Jamieson 2003).

The MABF was also actively involved at the national level by participating on the BOD of the Canadian Biosphere Reserve Association (CBRA) and with participants from other biosphere reserves in documenting Canadian achievements (Jamieson *et al.* 2008). The nature and sophistication of biosphere programmes in sustainable development was described, and it was shown that while much variability in capacity existed across Canadian biosphere reserves, the biosphere reserve concept with respect to the achievement of sustainable development was widely embraced by all communities in Canada associated with biosphere reserves. There was a wide diversity of initiatives, and Canadian efforts to develop biosphere reserve models of sustainable development at the community level were showing successes, largely because of great imagination and volunteer dedication. The CBRA was ultimately successful in receiving a commitment to five years of federal funding (approximately $57,000 per year per BR), starting in 2008, for all the Canadian BRs except for the Clayoquot Sound BR, which had its own

government sourced endowment fund. Unfortunately the five-year program was terminated one year early in 2012 as part of general cutbacks across the public service, with the resulting implications discussed below.

MABR Funding Acquisition Initiatives

Starting in 2003, there were two unique funding initiatives undertaken in the MABR, one under the biosphere name and the other through a separate society created to provide support for the biosphere, separate because it involved people not directly involved with the MABF. The first looked at establishing a Vancouver Island Biosphere Centre (VIBC) within the biosphere boundary, and to this end, funding was obtained from the City of Parksville and the Regional District on Nanaimo for three studies, an initial conceptual study, a feasibility study, and then a more detailed architectural study for a specific site. The VIBC was designed to be a physical building/structure that would showcase and interpret the exceptionally rich and diverse inventory of natural and cultural heritage resources that exists locally on Vancouver Island. The intent was to focus on increasing awareness of regional protected areas, their need to be effectively managed, and to highlight that protected areas can contribute economic value to local communities. The challenges in its establishment were to identify a potential physical location for the centre that: 1) offered natural habitats around the centre for interpretative walks; and 2) was acceptable to the community. A pre-design investigation that started in 2008 identified a "straw dog" site within Rathtrevor Provincial Park, one of the BR's core areas. However, public opposition to the commercialization of parkland ended conceptual-only discussions on this site, and the Centre remains at a pre-design stage to this day until another site can be determined.

The other funding initiative was founded through a separate registered society, the Oceanside Monetary Foundation (OMF). The purpose of the OMF was to raise funds for Oceanside (the local name for the Mount Arrowsmith Biosphere Reserve area) community projects, promote a sense of regional pride, and foster local economic activity and autonomy. The Foundation created "Oceanside Dollars" that were a paper currency that could be purchased at local financial institutions and businesses and used throughout the area as regular paper currency at par with the Canadian Dollar. The Oceanside dollars resembled the Canadian paper currency in dimension and had a printed expiry date about two years from the date of issue. Certificates that were not redeemed by their expiry date created revenue for the OMF, as did the interest earned on the Canadian dollar reserve being held in the banks until each currency issue's expiry date. There was a favourable response from local businesses and the program lasted for two years.

While this concept was unique among biosphere reserves worldwide, it encountered some start-up problems that eventually led to its demise:

1. The bills had the latest state-of-the-art anti-counterfeiting technologies built into them: they were printed on Teslin®, a synthetic printing substrate, additional corresponding UV bill serial numbers could be seen under ultraviolet light, and there was an image of a "ghost salmon" over the director signatures. However, unanticipated, the first printing on the then new plastic bills was "softer" than on the existing regular Canadian paper currency, which resulted in scratches on the bills when they were run through financial institution paper bill counting machines, which effectively destroyed them. They could not thus be counted this way, which created problems for the financial institutions that were supporting the initiative. Although this issue was soon resolved, it was not quick enough to overcome some negative public relations that occurred in the first year following bill release.

2. The success of the program depended on getting a large amount of Oceanside Dollars into community circulation as quickly as possible. In hindsight, greater efforts on communication and promotions were needed. The sales methods used targeted community markets and craft fairs, which was somewhat successful but time consuming, given the relatively little amount of Oceanside Dollars that ultimately entered into circulation. In hindsight, it would have been better to try and engage local groups such as Rotary, etc, and to ask their members to buy bills so as to get the bills into circulation faster.
3. The trend toward a "cashless" society with the increasing usage of credit and debit machines meant that local residents were less likely to use cash (or Oceanside Dollars) for their purchases.
4. The denominations of the bills ($1, 2, 5, 10 and 20) were larger than most change given by businesses for many small cash purposes, which was generally in coins.
5. The $1 and $2 bills in Canada had also recently been entirely eliminated from circulation, being replaced by coins, called in Canada the "loonie" (it had an image of a loon on it) and "twoonie," respectively.

At the close of the program, approximately $25,000 was placed into circulation, far short of the intended hundreds of thousands that had been hoped for. However, the program was still an imaginative and innovative fundraising initiative, and did increase MABR awareness within the community. On another positive note, it also represented the world's first unique biosphere reserve currency.

Mount Arrowsmith Biosphere Reserve - 2009 – 2014

The years between 2009 and 2014 proved to be an incredible challenge for the MABR

but in the end, a positive outcome was achieved. During this time, the MABF suffered communication challenges including BOD disputes, difficulty retaining volunteers and staff, and a loss of funding when the Federal contribution agreement to Canadian Biosphere Reserves was cancelled in 2012. This period of difficulties in part took hold in 2009 following an Annual General Meeting (AGM) of the society, when none of the existing directors, including Dr. Jamieson, were re-elected to the Board of Directors, although Dr. Jamieson did remain as a society member. Being the only "environmental" group at the time with dedicated federal funding, management of the society was taken over by a surge of new members that hoped to advance a more advocacy-driven agenda, with their sudden joining the society facilitated by the inexpensive ($5) society membership fee.

Meeting minutes made by MABF board members show that the period from 2009-2010 was a very difficult year for the organization because of core differences in MABR direction. Essentially, the MABF was in survival mode. Only three of the new directors persisted throughout much of 2010 and the first Coordinator hired had to be let go due to delays in the receipt of the approved federal funding. As shown by the minutes of the MAB, existing directors did not meet regularly as a result of an internal breakdown in communications and little progress was made in addressing the mandate of the organization during this time. Despite this breakdown, the BOD did undertake a hiring campaign and was able to bring on both a new Coordinator and a Communications Assistant in early 2011, as well as attract several new directors who together enabled a successful governance transition for the MABR in 2014 (described below).

In addition, there was the unfortunate timing of the first MABR Periodic Review, which began during the summer of 2010, as each biosphere reserve must undergo a formal evaluation every ten years. Recommendations from the review provide the basis for

decisions made by UNESCO's International Advisory Committee (IAC) on the progress and fate of a designation. Periodic Reviews are organized by the host country's national MAB Committee, and reviewers are assigned on a volunteer basis. Despite the fact that there were severe issues with funding, capacity and fierce internal disagreements, the MABF was able to host UNESCO researchers and facilitate the Periodic Review process. The reviewers spent several days interviewing MABF directors and members to compile information on how the society was operating for their review. Directors and staff of the MABF did not hear the results of the review until May 2011, and unsurprisingly, the review was not positive, but provided constructive recommendations. The MABF was then required to submit a Strategy and Action Plan that addressed these recommendations to the IAC by 2013, which if not accepted, would mean its loss of biosphere reserve designation.

Concerns identified by the review committee related to "not achieving the mandate of biosphere reserves, poor communications, limited community and First Nations involvement, and a lack of progress on local initiatives". The problems that existed were well known by the MABF executive. However, a lack of procedure at Board meetings and the perceived advocacy role of Biosphere Reserves by some of the new MABF Directors and members remained key impediments to moving forward. It was noted by Directors and staff, including Karen Hunter, that not all Directors were willing to embrace UNESCO's requirement for biosphere reserves to provide a community space for dialogue on sustainability and continued to promote an anti-development agenda. However, work on the education and science mandate of BRs was developed and led by MABR staff and volunteers through this time, and good progress was made through several initiatives. Some of the federal funding allocated to the MABR supported a publication on the status of the MABR (Clermont 2012), environmental education

initiatives, a monitoring of marine invasive species project, and joint community removal initiatives for terrestrial invasive species within the MABR boundary.

Internal communications among the MABF BOD completely broke down in 2011 and a gap in the MABF's bylaws regarding how to deal with such conflict left the BOD with few options. By the 2011 AGM, the nature of the break down was publicly voiced by Directors and members through speeches and grandstanding, but suggested changes to the bylaws promoted by the majority of the Board did not pass a vote (75% + 1). Proposed mediation to try and resolve differences within the BOD was put forth as a recommendation, but this failed to receive unanimous support.

For the remainder of 2011, much of the early energy and resolve that had sustained the biosphere reserve was reduced, but funded programming continued to be delivered by staff. Board meetings were cancelled for a brief period and when they resumed, one Director resigned and there were considerable lapses in attendance by another. However, the small group that remained continued to work towards the goal of developing and submitting a Strategy and Action Plan to the IAC as required including: completing reporting requirements required by the BC Society Act and Environment Canada, the federal funding agency, supporting existing programs and initiatives, and revising the governance of the MABF. The latter included the suggestion to close the Society and pass on the privilege of managing the MABR to others.

In 2012 and 2013, much of the small working Board's activities focused on both gathering information and preparing the MABR Strategy and Action Plan to respond to issues raised by the earlier Periodic Review and investigating alternate management systems for the MABR. In July 2012, the MABF Board proposed that the Regional District of Nanaimo manage the MABR as a Community Service. This proposition was

declined principally due to the financial obligations of a new Service, but soon after, the City of Parksville Council passed a resolution to give the MABF minimal administrative support while it pursued other governance options. The MABF AGM in 2012 occurred without incident, and no general meeting occurred in 2013, as is permitted by BC Society Act regulations.

Regular discussions continued in 2013, and a community-university management partnership for the MABR between Vancouver Island University (VIU) and the City of Parksville began to emerge for the management of the biosphere reserve. In mid-year, a Memorandum of Understanding outlining this partnership was drawn up and put forward to both the University and City for consideration. This news was communicated to CBRA, the CCU and Canada MAB through email channels, and presented in person to officials at the bi-annual meeting of EUROMAB, which that year took place in Brockville, Ontario. MABR representatives who attended this meeting believed that the positive communications at this meeting were instrumental in deciding the fate of MABR.

In 2014, news from UNESCO disseminated via Canada MAB stated that the MABR's Strategy and Action Plan had been accepted and the threat of losing BR designation was eliminated. Dissolving the MABF was then immediately proposed and accepted by the MABF membership, with the understanding that the management of the MABR would then be passed to a new governing body comprised of Vancouver Island University, the City of Parksville, and other future members with jurisdictional interests in the MABR. A final MABF AGM was held to announce and celebrate the transition of the MABR designation to the new partnership.

The Mount Arrowsmith Biosphere Region – 2014 to the present

The new MABR governance model includes VIU, the City of Parksville, Snaw-Naw-As First Nation, Qualicum First Nation, two private forestry companies, the Town of Qualicum Beach, representatives from provincial agencies, and two community members. The Board operates as a Roundtable with quarterly meetings that address issues of shared interest.

An initial action undertaken by the Roundtable was the renaming of the entity as the Mount Arrowsmith Biosphere Region (instead of Reserve). This change was made for several reasons: 1) the term "reserve" has a legal meaning in Canada, relating to the assigning of lands for Canada's Indigenous communities; 2) the term has other English meanings that imply that a "reserve" is an area that is somehow protected or preserved from development, which is incorrect for most of the MABR's area; and 3) the area is more accurately a region than a reserve by geographic definition.

In addition to the Roundtable, faculty and students at VIU initiated the development of a new research institute with a focus on creating new applied, community-based, participatory research initiatives that connect issues in the community to undergraduate and graduate student researchers. The Mount Arrowsmith Biosphere Region Research Institute (MABBRI) was founded in mid-2014 and to date has funded the involvement of over 120 students in a wide variety of research projects. Highlights include working with the City of Parksville on a Community Park Master Plan and Parks and Trails Plan, with the Snaw-Naw-As First Nation on a "Garden of Spiritual Healing", eelgrass and bull kelp monitoring projects, and various other marine and terrestrial based restoration and mapping projects. To finance this, the Institute has been successful in attracting substantial funding from a wide variety of foundations and government sources.

The new management structure and the activities being conducted by the Institute have thus led to significant advancement in achieving the mandate and goals of the MAB Programme. The management structure – a roundtable – is recommended for other biosphere reserves grappling with issues of contested space and jurisdiction. All roundtable members, which at present do not include the authors of this article, recognize that the seven First Nations with unceded territory on the east side of Vancouver Island where the MABR is defined hold the closest ties to the land and water and the strongest jurisdiction. The members also recognize that while there is very little land in the MABR that is classified as parkland by any level of government, creative ways need to be found to benefit the human/nature connection. Taking a solution-focused approach has also worked well for the roundtable, as has the adoption of a meeting "Culture of Engagement" document, which states:

"At the Mount Arrowsmith Biosphere Region Roundtable, we engage with one another and with the land and culture around which we gather in the following ways:

1) We acknowledge the Traditional Territories within which our meetings are held.
2) We demonstrate respect for Indigenous protocol as individuals and as a group, upholding the MABR's Guiding Principles for Collaboration with First Nations.
3) Our communication is open, honest, transparent and unemotional, and we are comfortable and willing to discuss potentially sensitive topics.
4) Before entering the gathering place, we hang bad feelings on a nail outside the door.
5) We work together to reach common goals for the betterment of our region.
6) We leave personal wants outside.
7) We are open to new perspectives, we seek to understand where each person is coming from, and we share information and beliefs in an environment of trust.
8) We listen to each other and work together to ensure that everyone has an opportunity to speak.
9) We keep personal stories that are shared in confidence inside this room.
10) We arrive and depart feeling at ease, and we look forward to meeting again."

The MABRRI has also been a significant feature in the new success of the MABR. The energy and endless capacity of students to engage in community-based applied research

has enabled the MABR to raise its profile among both the world-wide biosphere reserve scientific community and, more importantly, the local community. Vancouver Island is known to be a prime destination for retirees from across Canada and the United States, and many of these individuals bring decades of experience relating to the human/nature connection. MABRRI has accessed some of this knowledge through the development of Technical Advisory Committees which bring local residents in to advise students on project development and protocols, and increasing these ties to community is the major focus of MABRRI in 2018/19.

Lessons Learned Over 20 Years

1. Margaret Meade stated that "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has." This was true with respect to achieving recognition of the MABR. However, moving forward after recognition without any dedicated funding posed challenges that in hindsight perhaps should have been dealt with differently. The approach adopted was to try to obtain funding directly from its own initiatives, whereas perhaps the focus should have been on establishing different and more appropriate connections and collaborations within the community to allow engagement of a broader group in this endeavour.

2. Funding (or the lack of funding, more specifically) was always an issue for the MABR, even before it became designated as a biosphere reserve. It is difficult to attract volunteer resources when the first agenda item is always "fund raising," and trying to develop a different approach might in hindsight have been desirable from the outset.

3. The overarching biosphere reserve concept can be difficult for many to grasp and

identify with: working toward achieving sustainability is a more nebulous goal than undertaking a specific activity, such as building a fish ladder or removing invasive species. In the MABR Area, there are many existing groups working on important, specific, task oriented initiatives, and instead of duplicating these, a biosphere management committee is better suited to: 1) act as a coordinating umbrella organization over a variety of community initiatives, and so support many initiatives and identify where gaps may exist in the overall achievement of cultural, economic and environmental sustainability; and 2) to participate in international in long-term monitoring activities efforts, such as GLORIA and with Smithsonian Biodiversity monitoring protocols. Communication on these facts is extremely important, and should be a major component of any biosphere reserve's activities to ensure maximum buy-in to the concept. The MABF in its early stages neither had the capacity nor resources to achieve this as successfully as was desired.

4. It is important to think and act outside the "box of convention" as demonstrated by Dr. Jamieson's success in achieving initial MABR recognition. While acknowledging that community projects require buy-in by society in their initial phases to be acceptable to key players, community inclusion does not necessarily need to follow established formats. Establishing the MABR in the early 2000s was in hindsight again too constraining. It is a perhaps one of the reasons why UNESCO altered the designation application to be very specific about the nature of community level support desired. In British Columbia, societies and not-for-profit groups generally have an open membership that is achieved through registration or the payment of a membership fee. For the MABR, in an effort to be as inclusive as possible, membership was open to all with only a relatively inexpensive annual membership fee that allowed for BOD take-over with minimal effort. For the first 14 years when the MABF had no significant funding, this was not an issue, largely

as membership was low (6 to 20 members per year). However, once some significant operational funding was realized in 2008, members from other more advocacy-focused groups in the community saw this as a way to advance their own specific interests. An open membership process allowed the entire Board of Directors of the MABF to be changed at the 2009 AGM, i.e., to have the agenda of the society replaced and determined by a new slate of elected directors that were not focused on achieving either UNESCO's requirements or the BR mandate. Again in hindsight, society membership should thus have been restricted. This kind of open governance structure is therefore not recommended for societies that hope to achieve a functional process for BOD appointment and replacement. Unpredictably, stable funding under these circumstances did not support the achievement of required identified BR objectives. The new MABR management structure now being used has avoided this problem by implementing a roundtable governance model (i.e., no open membership, and with both appointed directors and community advisors to the board) that meets to discuss issues of shared interest and to create opportunities for the Research Institute.

5. In Biosphere Reserves a poor level of funding can hinder the acquisition of committed volunteers and thus BR actions as they attempt to meet MAB objectives outlined in the Seville Strategy (1996) and the Madrid Action Plan (2008-2013). In the case of the MABR, there was burn-out among the few committed directors, and frustration among experienced directors because of the lack of resources to achieve what they desired to do. The result was great director turnover and a lack of capacity, with the resulting inability to really achieve the full potential of the biosphere reserve concept.

6. Biosphere Reserves require strong local leadership and ties to local governance in

order to realize and implement the BR concept. If local governments do not value the BR as a community asset, it will be less likely to achieve outcomes over time that will be satisfactory to UNESCO. In the case of the MABR, the value of the BR concept was recognized by local communities, even with all the challenges that occurred after 2009, which was why a new, more functional management model was ultimately developed for the MABR. With strong municipal government support and the active involvement of the local academic research community, i.e., MABBRI and Vancouver Island University, the MABR has overcome its early operational difficulties and has now become an effective, dynamic, functional organization.

Summary

This report outlines the developmental history of the MABR from its conception in the early 1990s through its evolution into an effective, functional biosphere region in 2016. There have been many successes and challenges over this time period, but the end result is positive and the momentum is now in place to lead to significant future achievements. While many challenges remain, notably around ongoing funding, there is widespread community support for this biosphere region and many active projects are now underway. It is hoped that by documenting our experiences, other biosphere regions (reserves), and those under consideration can learn from our setbacks and achievements.

Acknowledgements

We thank Dr. Pam Shaw, VIU, for her constructive comments, her adding the most recent descriptions of how the MABR is now structured, its achievements and its on-going projects; and for her coordination in publishing this document. As with most BR initiatives, many people have contributed over the past 25 years to where we are today, and their support and efforts are recognised and appreciated. The authors especially wish

to especially acknowledge the hard work and dedication of Kari Nelson, Chris Burger, Nicole Muchowski, Joy Wade, Jim Boggs, David Witty, Holly Clermont, and Peter Rothermel, all MABF Directors who were a joy to work with and who were absolutely essential to the establishment and ultimate successful outcome of the MABR.

References

Canadian Biosphere Reserves Association (CBRA). 2012. CBRA Annual Report 2012-2013. 25 pp. Available at: http://static1.squarespace.com/static/5735fdc137013b8eeb217d63/t/57a8c43dd482e9bbf170d516/1470678086884/2012-13_Annual-Report_CBRA.pdf

Clermont, H., (Ed.) 2011. The State of Mount Arrowsmith Biosphere Reserve: Global and Climate Change in Mountain Sites (GLOCHAMOST) Report 2011. Available at: http://unesdoc.unesco.org/images/0021/002147/214702E.pdf

Fraser, R. and G. Jamieson. 2003. Community Environmental Education: Challenges Within the Biosphere Reserve Concept. *Prospects* 33 (3): 293–302. DOIhttps://doi.org/10.1023/A:1025531610879

Jamieson, G.S. 1997a. A proposal for the Mount Arrowsmith World Biosphere Reserve. *Leading Edge 97, The Edge and the Point Conference*. Session 6: 289-292.

Jamieson, G.S. 1997b. Establishing a Biosphere reserve: The proposed Mount Arrowsmith World Biosphere Reserve Experience. *Leading Edge 97, The Edge and the Point Conference.* Session 6: 285-288.

Jamieson, G., G. Francis, G. Whitelaw and N. Ruttan. 2008. Canadian biosphere reserve approaches to the achievement of sustainable development. *International Journal of Environment and Sustainable Development* 7(2): 132-144.

Madrid Action Plan. 2008-2013, http://unesdoc.unesco.org/images/0016/001633/163301e.pdf . 32 pp.

Seville Strategy. 1996. http://unesdoc.unesco.org/images/0010/001038/103849Eb.pdf. 19 pp

Dr. Glen Jamieson was a federal Fisheries and Oceans research scientist when he initiated the Mount Arrowsmith Biosphere Reserve initiative in 1993, initially in stock assessment and later in conservation biology, before retiring as an emeritus scientist in 2008. After 2009, while no longer directly involved in MABR management, he participated "behind the scene" in helping to achieve a new management structure to overcome the problems described above, and continues to support the MABR in whatever way he can.

Karen Hunter is a biologist who was hired in January 2011 as the MABR Coordinator. When funding terminated in 2012, she became a Director of the MABF where she represented MABR at regional, national, and international levels, and led the transition of the MABR to its new administrative home in 2014. Karen has been employed as the Climate Response Program Lead at Fisheries and Oceans Canada, Science Branch, since 2012.

The analysis of mangrove forest changes period of 20 years in Can Gio Biosphere Reserve, Viet Nam using remote sensing and GIS technology

Luong Viet Nguyen[1*]

Tu Trong To[1]

Hong Xuan Trinh[1]

Thu Thuy Luu Hoang[2]

1 Remote Sensing Application Department, Space Technology Institute-Vietnam Academy of Science and Technology, A22-18 Hoang Quoc Viet str., Cau Giay dist., Hanoi 10000, Vietnam.
2 Geo-Climatology, Institute of Geography, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet str., Cau Giay dist., Hanoi 100000, Vietnam.

Abstract

On January 21, 2000, the MAB/UNESCO Committee recognized the Can Gio mangrove forest as an International Biosphere Reserve. The MAB/UNESCO committee requires every potential biosphere reserve to be assessed for a period of 10 years. During this time, the ecology of the area is closely reviewed, including the vegetation cover. This study used 45 sample plots in the field and utilized Remote Sensing and Geographic Information Systems (RS & GIS) technology for mapping, allowing for the close observation of changes in the mangrove forest during a 20 year period (1996-2016). The results show that, from the SPOT, Landsat 8 OLI satellite imagery, we can categorize the land cover maps in Can Gio Mangrove Biosphere Reserve, including periods of 1996, 1999, 2004, 2009 and 2016, into six classes: dense mangrove forest,

open mangrove forest, young mangrove forest and scrub, agriculture land, water body, and barren land. The accuracy of the land cover maps for 1996, 1999, 2004, 2009 and 2016 was high, with scores of 84.89 percent, 83.89 percent, 87.78 percent, 82.78 percent, and 84.44 percent, respectively.

Keywords: Mangrove forest, monitoring, remote sensing, GIS

Introduction

Vietnam is located on the Indochinese Peninsula, and has a 3,260 km long coastline. Of the eight International Biosphere Reserves (IBRs) in Vietnam, seven IBRs are positioned along the coast and including rich natural resources, such as mangroves (Hong et al., 1997). Vietnam is one of the countries most affected by climate change. In recent years, we have seen an increase in irregular weather and natural disasters, especially in the form of storms and floods. Droughts and floods have caused widespread damages to the country in 2006, 2007, 2009, and 2015. In areas of southern Vietnam, such as Ho Chi Minh city and Can Tho Ca Mau, provinces that had never suffered from floods in the past, are now regularly hit. In June 2009, the Ministry of Natural Resources and Environment conveyed concerns regarding climate change, and asked the departments to develop an action plan addressing the threat of rising of sea levels. According to the Ministry's calculations, the temperature in Vietnam will have increased by 2.3^{o}C, and most of the area in the southern provinces (agricultural land, residential land, mangrove forest, etc.) will be flooded by the end of the 21st century (Tran Thuc et al., 2016). The Can Gio Biosphere Reserve, lying entirely within the Can Gio district in southern Vietnam, is an important mangrove forest ecosystem, and is regarded as the "green lungs" of the region (Nguyen Hoang Tri et al., 2000). Due to its international significance, it was recognized as the first International Biosphere Reserve in Vietnam by the MAB/UNESCO committee in 2000 (UNESCO, 2000). After serious damage suffered during the Vietnamese war, the reserve is now under threat of global

climate change and rising sea levels along the Mekong river. There are around 58,000 people living within the boundaries of this reserve, and approximately 54,000 people living in the transition area (Tuan et al., 2002). The local people are of various origins and ethnical groups; Consequently, a mixture of culture and social systems is inherent to this region. The main economic activities are agriculture, fisheries, aquaculture, and salt production. Most of the families in this region must earn their livings by catching crabs and mollusks, and by collecting firewood. The livelihood of the local people depends on mangrove forests, either directly or indirectly. The scientific management of the mangrove forests is extremely important, not only for the conservation of natural coastal environments, but also for safeguarding the livelihood of thousands of local people.

The purpose of this study is to monitor the mangrove forests of the Can Gio Biosphere using remote sensing data and geographical information system (GIS) technology, and help protect an important biosphere reserve of both Vietnam and the world.

STUDY AREA

Can Gio mangrove forest lies entirely within the district of Ho Chi Minh City, on the geographic co-ordinates of are $10^{o}22'14$N to $10^{o}40'09''$N latitude and $106^{o}46'12''$E to 107^{o} 00' 59'' E longitude. The reserve is located south of Nha Be district, and north of Dong Nai and Ba Ria – Vung Tau and Long An sit to the east and west, respectively. The area measures 35 km from North to South and 30 km from East to West (Tuan et al., 2002; Hirose et al., 2004) (Figure No. 1).

Figure No. 1. Local map of study area (Can Gio Biosphere Reserve)

DATA AND METHODOLOGY

In this study, we used five optical satellite images: SPOT 4 of 1996, 1999, SPOT 5 of 2004 and 2009, and Landsat 8 OLI 2016. Data for 1999, 2004, and 2009 was acquired from the works of Luong and Singh (Luong., 2009, 2011; Singh and Luong 2013). The optical satellite used in the present study are shown in Figure No. 2.

.

(a.)

(b.)

(c.)

(d.)

(e.)

Figure No. 2. False colour composite of (a.) SPOT HRV in 1996, (b.) 1999, (c.) 2004, (d.) 2009, (e.) Landsat 8 OLI in 2016.

FIELD WORK

In total, 45 sample plots were used in this study. The diameter of all the trees larger than 5 cm in diameter were measured at breast height (D) and full height (H). The tree diameter and height were measured by using laser instruments, and the central geo-location (latitude and longitude) of each sample plot was recorded with a GPS device. The average forest parameters (units per hectare) in each plot were calculated according to the guidelines provided by Hong et al., 2006. The summary of results from filed work are shown in Table No. 1.

Table No. 1. Summary of forest inventory parameters in Can Gio Mangrove Reserve

Parameter	**Forest inventory parameters**			
	Minimum	Maxmum	Mean	Standard Deviation
Diameter (m)	5.83	17.60	11.10	3.25
Height (m)	6.34	17.04	13.84	2.85

Parameter	Forest inventory parameters			
	Minimum	Maxmum	Mean	Standard Deviation
Woody volume ($m^3.ha^{-1}$)	8.27	206.03	136.56	64.26

(a)

(b.)

(c.)

(d.)

(e.)

(f.)

Figure No. 3. Photo from field work: (a.) Dense mangrove forest, (b.) Open mangrove forest, (c.) Young mangrove forest, (d.) Scrub, (e.) Agriculture land, (f.) Barren land

LAND COVER CLASSIFICATION

The classification scheme is based on the objectives or requirement of the user. In this study, we used five satellite images, four of the five from SPOT satellites including SPOT in 1996, 1999, 2004, 2009 and one of them from Landsat 8 satellite in 2016. The selected satellite images did not differ much about time observed per the years, it is an advantage to accurately detect changes in mangrove forest over time. The classification makes easily use to mangrove forest manager, and also conformity with criteria for the classification by Vietnam (MARD, 2009), and was adopted classification criteria of the UNESCO (1973) and Thai Van Trung (1998) systems. The classification scheme land covers in this study are described following:

- Level 1 (main classes) has two classes: Forest land and Other land (none forest).
- Level 2 (Sub-classes) has six classes: Dense mangrove forest (dense forest), Open mangrove forest (open forest), Young forest&scrub (young forest and scrub mixed), Agriculture land, Water body, and Barren land.

PROCESSING OF SATELLITE DATA

The processing of satellite data in this study included geometric correction, image to map rectification, image registration, image fusion, and change analysis (Laben et al., 2000; Luong et al., 2015). Supervised classification method was used. The supervised classification is the process of sampling a known identity, in order to classify pixels of unknown identity. Samples of known identities are pixels located within training areas. Pixels located within these areas are used to guide the classification algorithm, assigning specific spectral values to appropriate information classes. There are three basic steps to the supervised classification procedure: define signatures, evaluate signatures, and process a supervised classification.

RESULTS

Land cover mapping

Land cover map in 1996

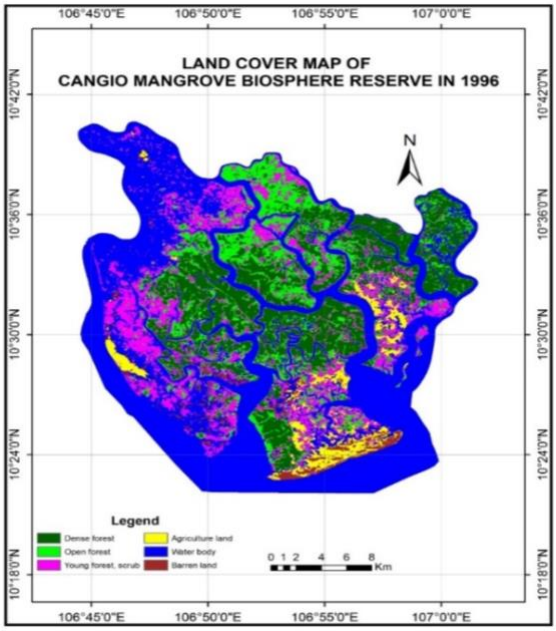


Figure No. 4. Land cover map in 1996

The statistical results from the land cover map in 1996 were comprised of 20.22 dense forest area, 12.12 percent open forest, and 15.82 percent young forest and scrub. Water accounted for 46.29 percent, while both agricultural and barren land made up 3.56 percent, see at Table No. 2 and Figure No. 4.

The overall accuracy of this data is 84.89

percent, with an average accuracy of 82.95 percent (Kappa statistics (K) is 0.7994).

Table No. 2. Area statistics of land cover in Can Gio Biosphere Reserve in 1996

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
Forest land	Dense forest	1496933	14969.33	20.22
	Open forest	897561	8975.61	12.12
	Young&scrup	1171464	11714.64	15.82
	Sub-total		***35659.58***	***48.16***
Other land	Agriculture land	263693	2636.93	3.56
	Water body	3428002	34280.02	46.29
	Barren land	147222	1472.22	1.99
	Sub-total		***38389.17***	***51.84***
Total			**74048.75**	**100.00**

Land cover map in 1999

The land cover map based on the supervised classification of SPOT 1999 had given in Figure No. 5 and the statistical results of land cover had given in Table No. 3.

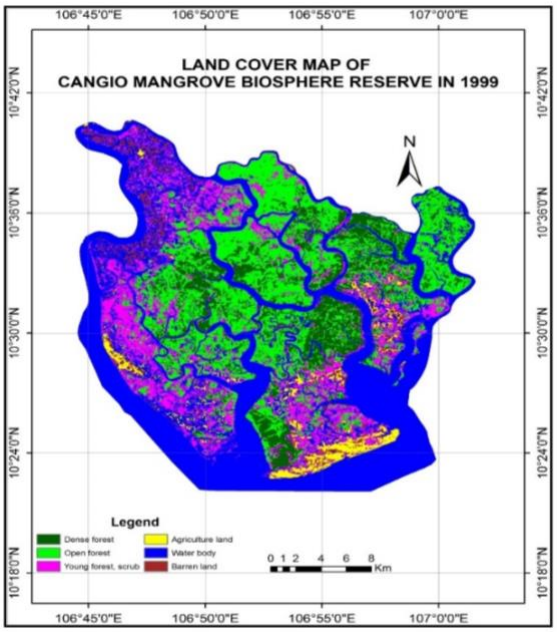


Figure No. 5. Land cover map in 1999

The dense forest area is 13.89%, open forest is 23.73%, young forest and scrub are 15.83%, agriculture land is 2.76%, water body is 41.67% and barren land is 3.11%.

Table No. 3. Area statistics of land cover in Can Gio Biosphere Reserve in 1999

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
Forest land	Dense forest	954698	9546.98	12.89
	Open forest	1757084	17570.84	23.73
	Young&scrup	1172494	11724.94	15.83
	Sub-total		***38842.76***	***52.46***
Other land	Agriculture land	204564	2045.64	2.76

	Water body	3085532	30855.32	41.67
	Barren land	230503	2305.03	3.11
	Sub-total		***35205.99***	***47.54***
Total			**74048.75**	**100.00**

Classification accuracy assessment based on confusion matrix. The results of the overall accuracy is 83.89% and average accuracy of 81.95%. Kappa statistics (K^) is 0.7894.

Land cover map in 2004

The land cover map based on supervised classification of SPOT 2004 had given in Figure No. 6 and the area analysis of land cover had given in Table No. 4.

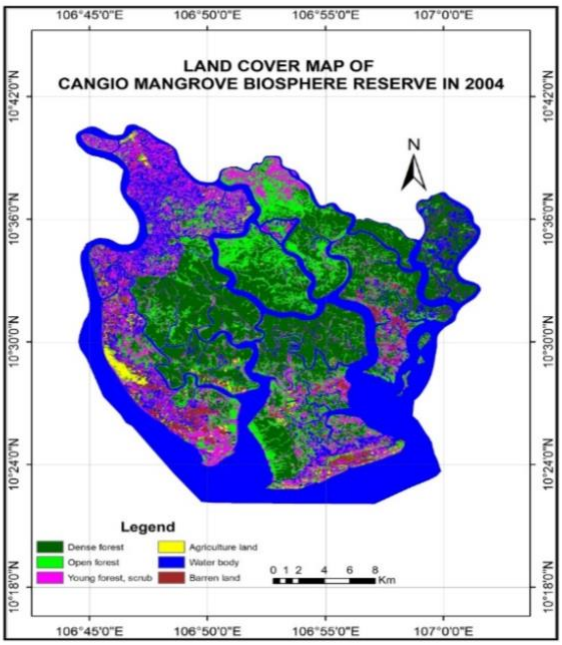


Figure No. 6. Land cover map in 2004

The dense forest area is 27.01%, open forest is 14.38%, young forest and scrub are 14.53%, agriculture land is 1.26%, water body is 39.65% and barren land is 3.16%.

Table No. 4. Area statistics of land cover in Can Gio Biosphere Reserve in 2004

Main classes	**Sub-classes**	**Pixel count**	**Area**	
			Hectare (ha)	**Percent (%)**
Forest land	Dense forest	2000306	20003.06	27.01
	Open forest	1064922	10649.23	14.38
	Young&scrup	1075806	10758.08	14.53
	Sub-total		***41410.37***	***55.92***

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
Other land	Agriculture land	93606	936.06	1.26
	Water body	2936131	29361.03	39.65
	Barren land	234105	2341.29	3.16
	Sub-total		***32638.38***	44.08
Total			**74048.75**	**100.00**

The classification accuracy based on confusion matrix had estimated. The results of the overall accuracy of mapping is 87.78% and average accuracy of 82.90%. Kappa statistics (K^) is 0.82%.

Land cover map in 2009

The land cover map based on supervised classification of SPOT 2009 had given in Figure 7 and the area analysis of land cover had given in Table No. 5.

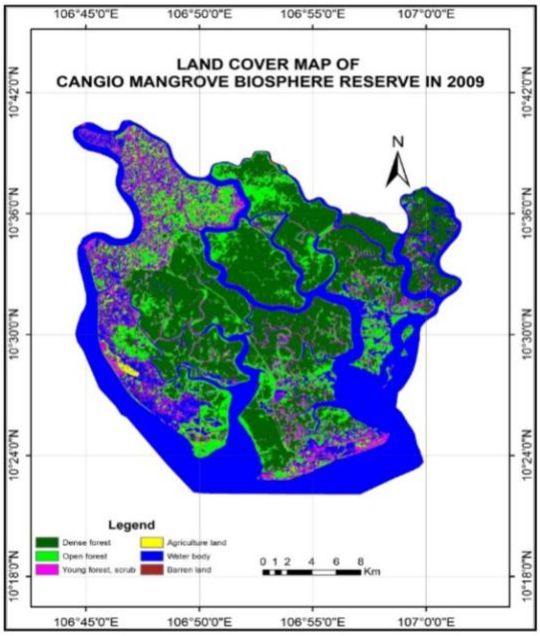


Figure No. 7. Land cover map in 2009

The dense forest area is 32.62%, open forest is 16.38%, young forest and scrub are 14.53%, agriculture land is 1.26%, water body is 39.65% and barren land is 3.16%.

Table No. 5. Area statistics of land cover in Can Gio Biosphere Reserve in 2009

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
Forest land	Dense forest	2415361	24153.61	32.62
	Open forest	1251370	12513.70	16.90
	Young&scrup	802878	*8028.78*	10.84
	Sub-total		***44696.09***	***60.36***
Other land	Agriculture land	109498	1094.98	1.48

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
	Water body	2699259	26992.59	36.45
	Barren land	126509	1265.09	1.71
	Sub-total		***29352.66***	***39.64***
Total			**74048.75**	**100.00**

The accuracy assessment based on confusion matrix. The results of the overall classification accuracy based on confusion matrix is 82.78% and average accuracy of 70.00%. Kappa statistics (K^) is 76.09%.

Land cover map in 2016

The land cover map based on supervised classification of Landsat OLI 2016 had given in Figure 8 and the area analysis of land cover had given in Table No. 6.

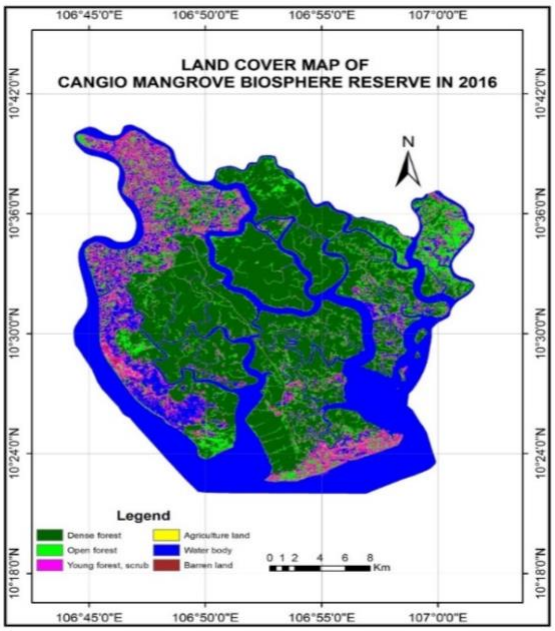


Figure No. 8. Land cover map in 2016

The dense forest area is 38.53%, open forest is 11.17%, young forest and scrub are 9.79%, agriculture land is 2.76%, water body is 34.07% and barren land is 3.69%.

Table No. 6. Area statistics of land cover in Can Gio Biosphere Reserve in 2016

Main classes	Sub-classes	Pixel count	Area	
			Hectare (ha)	Percent (%)
Forest land	Dense forest	1268111	28532.50	38.53
	Open forest	367447	8267.56	11.17
	Young&scrup	322096	*7247.15*	9.79
	Sub-total		***44047.21***	***59.48***

Other land	Agriculture land	90737	2041.58	2.76
	Water body	1165704	25228.34	34.07
	Barren land	76961	2731.62	3.69
	Sub-total		***30001.55***	***40.52***
Total			**74048.75**	**100.00**

The accuracy assessment based on confusion matrix. The overall classification accuracy based on confusion matrix is 84.44% and average accuracy of 70.00%. Kappa statistics (K^) is 76.09%.

Analyze the change of mangrove forests

The analysis of land cover changes of mangrove forest in Can Gio Biosphere Reserve over of 20 years (1996-2016), and divided into four periods are from 1996 to 1999, from 1999 to 2004, from 2004 to 2009 and from 2009 to 2016. In there are (+) Increase and (-) decrease. The detailed results of the analysis of land cover changes in study area in each period as follows;

Period from 1996 to 1999

The total area of forest land area has changed to 3,183.18 ha, there include rich forest (-5,422.35 ha), open forest (8,595.23 ha) and young forest and scrub (10.30 ha). Other land area has changed by 3,183.18 ha, there include agriculture land (-591.29ha), water body (-3,424.70 ha) and barren land (-3,183.18ha). The result are shown in Table No. 7.

Table No. 7. Land cover changed during 1996 to 1999; (+) Increase and (-) decrease

Sub-classes	**Area 1996**		**Area 1999**		**Changed area 1996-1999**	
	ha	%	ha	%	ha	%
Dense forest	14969.33	20.22	9546.98	12.89	-5422.35	-7.32
Open forest	8975.61	12.12	17570.84	23.73	+8595.23	+11.61
Young forest & scrub	11714.64	15.82	11724.94	15.83	+10.30	+0.01
Sub-total	***35659.58***	***48.16***	***38842.76***	***52.46***	***+3183.18***	***+4.30***
Agriculture land	2636.93	3.56	2045.64	2.76	-591.29	-0.80
Water body	34280.02	46.29	*30855.32*	*41.67*	-3424.70	-4.62

Sub-classes	Area 1996		Area 1999		Changed area 1996-1999	
	ha	%	ha	%	ha	%
Barren land	1472.22	1.99	2305.03	3.11	+832.81	+1.12
Sub-total	***38389.17***	***51.84***	***35205.99***	***47.54***	***-3183.18***	***-4.30***
Total	**74048.75**		**74048.75**	**100.00**		

Period from 1999 to 2004

The total area of forest land area has changed to 2,567.61 ha, there include rich forest (-1,0456.08 ha), open forest (-6,921.61 ha) and young forest and scrub (-966.86 ha). Other land area has changed by (-2,567.61 ha), there include agriculture land (-1,109.58 ha), water body (-1494.58 ha) and barren land 36.26 ha. The results are shown in Table No. 8.

Table No. 8. Land cover changed during 1999 to 2004; (+) Increase and (-) decrease

Sub-classes	Area 1999		Area 2004		Changed area 1999-2004	
	ha	%	ha	%	ha	%
Dense forest	9546.98	12.89	20003.06	27.01	+10456.08	+14.12
Open forest	17570.84	23.73	10649.23	14.38	-6921.61	-9.35
Young forest& scrub	11724.94	15.83	10758.08	14.53	-966.86	-1.31
Sub-total	***38842.76***	***52.46***	***41410.37***	***55.92***	***+2567.61***	***+3.47***
Agriculture land	2045.64	2.76	936.06	1.26	-1109.58	-1.50
Water body	30855.32	41.67	*29361.03*	*39.65*	-1494.29	-2.02
Barren land	2305.03	3.11	2341.29	3.16	+36.26	+0.05
Sub-total	***35205.99***	***47.54***	***32638.38***	***44.08***	***-2567.61***	***-3.47***
Total	**74048.75**	**100.00**	**74048.75**	**100.00**		

Period from 2004 to 2009

The total area of forest land area has changed to 3,285.72 ha, there include rich forest 4,150.55 ha, open forest 1,864.47 ha and young forest and scrub (-2,729.30 ha). Other land area has changed by (-3,285.72 ha), there include agriculture land 158.92 ha, water body (-2,368.44 ha) and barren land (-1,076.20 ha). The results are shown in Table No. 9.

Table No. 9. Land cover changed from 2004 to 2009; (+) Increase and (-) decrease

Sub-classes	**Area 2004**		**Area 2009**		**Changed area 2004-2009**	
	ha	%	ha	%	ha	%
Dense forest	20003.06	27.01	24153.61	32.62	+4150.55	+5.61
Open forest	10649.23	14.38	12513.70	16.90	+1864.47	+2.52
Young forest&scrub	10758.08	14.53	8028.78	10.84	-2729.30	-3.69
Sub-total	***41410.37***	***55.92***	***44696.09***	***60.36***	***+3285.72***	***+4.44***
Agriculture land	936.06	1.26	1094.98	1.48	+158.92	+0.21
Water body	29361.03	39.65	*26992.59*	*36.45*	-2368.44	-3.20
Barren land	2341.29	3.16	1265.09	1.71	-1076.20	-1.45
Sub-total	***32638.38***	***44.08***	***29352.66***	***39.64***	***-3285.72***	***-4.44***
Total	**74048.75**	**100.00**	**74048.75**	**100.00**		

Period from 2009 to 2016

The total area of forest land area has changed to 3,285.72 ha, there include rich forest (-648.88 ha), open forest (-4,246.14 ha) and young forest and scrub (-781.63 ha). Other land area has changed by 648.89 ha, there include agriculture land 946.60 ha, water body (-1,764.25 ha) and barren land 1,466.53 ha. The results are shown in Table No. 10.

Table 10. Land cover changed from 2009 to 2016; (+) Increase and (-) decrease

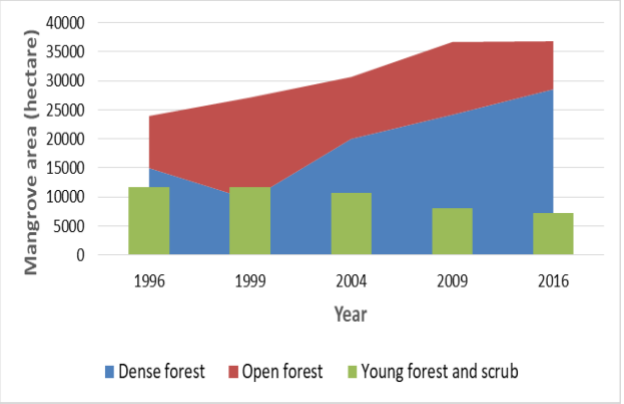
Sub-classes	**Area 2009**		**Area 2016**		**Changed area 2009-2016**	
	ha	%	ha	%	ha	%
Dense forest	24153.61	32.62	28532.50	38.53	+4378.89	+5.91
Open forest	12513.70	16.90	8267.56	11.17	-4246.14	-5.73
Young forest & scrub	8028.78	10.84	7247.15	9.79	-781.63	-1.06
Sub-total	***44696.09***	***60.36***	***44047.21***	***59.48***	***-648.88***	***-0.88***
Agriculture land	1094.98	1.48	2041.58	2.76	+946.60	+1.28
Water body	26992.59	36.45	*25228.34*	*34.07*	-1764.25	-2.38
Barren land	1265.09	1.71	2731.62	3.69	+1466.53	+1.98
Sub-total	***29352.66***	***39.64***	***30001.55***	***40.52***	***+648.89***	***+0.88***
Total	**74048.75**	**100.00**	**74048.75**	**100.00**		

CONCLUSIONS AND DISCUSSIONS

In this study, we have used satellite imagery from SPOT, Landsat OLI for

assessing mangrove forest dynamics at Can Gio Biosphere Reserve for 20 years (from 1996 to 2016). The results are summarized are shown in Diagram No. 1: The results show that; young and scrub mangrove forests area in Can Gio Biosphere have always been reduced over the periods from 1996 to 2016; there are in 1996 (11,714.64 ha); in 1999 (11,724.94 ha); in 2004 (10,758.08 ha); in 2009 (8,028.78 ha) and in 2016 (7,247.15 ha). Although according to the annual Can Gio Biosphere Reserve reports, the area of mangroves has been expanded by afforestation or regeneration of natural forests. However, some young forest areas have been converted into open mangrove forest and rich mangrove forest.

Statistical results from satellite images have also shown that; The open mangrove forest area has also increased over the period 1996 to 2009, there are in 1996 (8,975.61 ha); in 1999 (17,570.84 ha); in 2004 (10,649.23 ha) and 2009 (12,513.70 ha), and the area has not changed much in the periods from 2009 (12,513.70 ha) to 2016 (8,267.57 ha). The reasons are that the area of young mangrove forest converted to open mangrove forests, and some open mangrove forest area converted to the rich mangrove forest area are equivalent.



Histogram No. 1: Distribution of mangrove forests area over periods of 1996, 1999, 2004, 2009 and 2016

The study also showed that: The area of rich mangroves has always increased over the periods from 1996 to 2016, there area in 1996 (14,969.33 ha); in 1999 (9,546.98 ha); in 2004 (20,003.06 ha); in 2009 (24,153.61 ha) and in 2016 (28,532.50 ha). These are proven results for the conservation and development of mangroves that have been implemented well in Can Gio Mangrove Reserve, Vietnam.

Funding Sources

Nagao Natural Environment Foundation, Japan

ACKNOWLEDGMENT

The authors are grateful to Nagao Natural Environment Foundation, Japan for financial support to this research.

REFERENCES

Phan Nguyen Hong (1997). The Role of Mangrove forests in Viet Nam-Agriculture Publish House, Ha Noi, 1997.

Le Duc Tuan, Tran Thi Kieu Oanh, Cat Van Thanh, Nguyen Dinh Qui (2002). Can Gio Mangrove Biosphere Reserve. Vietnam Agricultural Publishing House, Ho Chi Minh city, 2002.

Hirose, K., Syoji, M., Hang, H. T. M., Anh, N. H., Triet, T., & Nam, V. N. (2004, September). Satellite data application for mangrove management. Japan-Vietnam Geoinformatics Consortium, 19 Le Thanh Tong Campus, Hanoi University of Science, Conference Hall, Hanoi, Vietnam

http://gisws. media. osaka-cu. ac. jp/gisideas04/.

MARD (2009). Viet Nam Circular 34/2009/TT-BNNPTNT 'Regulations on the criteria for identifying and classifying forest' in 2009.

UNESCO/MAB project- Valuation of The Mangrove Ecosystem in Can Gio mangrove Biosphere, Viet Nam, Ha Noi 8-2000.

Tran Thuc, Nguyen Van Thang, Huynh Thi Lan Huong, et al (2016). Scenario of climate change and sea level rise for Vietnam. Ministry of Natural Resources and Environment. Vietnam map and environmental resource publishing house in 2016.

Nguyen Hoang Tri, Phan Nguyen Hong, Le Trong Cuc, 2000. Can Gio Mangrove Biosphere Reserve.

Nguyen Viet Luong (2009). Final report- Mangrove forest structure and coverage change analysis using remote sensing and GIS a case study of Can Gio Mangrove Biosphere Reserve.

Nguyen Viet Luong (2011). The vegetation in Can Gio mangrove forest after 10 years of MAB/UNESCO recognized as an International Biosphere Reserve. The 4-th National Scientific Conference on Ecology and Biological Resources. October 21, 2011.

Sarnam, S., Luong, N.V, Binh, T.T.H. (2013). Mangrove Forest Reclamation Monitoring Using Geospatial Tools in Can Gio Mangrove Biosphere Reserve, Vietnam. *International Journal of Ecology and Environmental*

Sciences 39 (3): 147-158, ISSN: 0377-015X (Print); 2320-5199.

Laben, C.A and Brower, B.V. (2000). U.S. Patent No. 6011,875. Washington, DC: U.S. Patent and Trademark Office.

Hoang Pham, H. (2003) *Flora of Viet Nam*. Volume 1, 2, 3. Young Publishing House. Ho Chi Minh City, Vietnam, 2003.

Vo Van Hong et al. (2006). *Handbook for Vietnam forest inventory*. Ministry of Agriculture and Rural D

Bull Kelp (*Nereocystis luetkeana*) enhancement plots in the Salish Sea

Pamela Shaw, Ph.D MCIP RPP FRCGS
Vancouver Island University

William Heath, Ph.D
Project Watershed

Haley Tomlin, B.Sc
Vancouver Island University

Brian Timmer, B.Sc candidate
Vancouver Island University

Chrissy Schellenberg, B.Sc
Vancouver Island University

AUTHOR ADDRESS
Haley Tomlin
Vancouver Island University, 900 Fifth St, Nanaimo, BC V9R 5S5
Email: haley.tomlin@viu.ca

Keywords: bull kelp, environment, enhancement, Strait of Georgia

Introduction

Data regarding the abundance of bull kelp (*Nereocystis luetkeana*) along the east coast of Vancouver Island in British Columbia is limited, but there is evidence that bull kelp populations have been in steady decline within the central Strait of Georgia within recent decades (Lamb et al., 2011). In addition, local residents that frequent the coast have reported that *N. luetkeana* has been significantly declining in the Salish Sea over the past 30 years, becoming nonexistent in regions where it was previously abundant (Lindop, 2017). Reasons for significant declines of *N. luet-*

keana forests in the Salish Sea may include coastal development, rising ocean temperatures, local changes in oceanographic conditions (e.g. salinity, turbidity and sedimentation), intensified herbivore grazing or a combination of these factors (Steneck et al., 2002, Heath et al., 2017).

The Mount Arrowsmith Biosphere Region Research Institute (MABRRI) has undertaken a pilot project, attempting to re-establish bull kelp beds that have begun to diminish or have perished in the Salish Sea, specifically the Strait of Georgia. MABRRI's Bull Kelp Monitoring and Enhancement Plot project involved the installation of kelp enhancement plots at two different sites within the Strait of Georgia, including one located in the Winchelsea Islands, near the entrance of Nanoose Bay, and the other northwest of Dodd Narrows, in the Northumberland Channel (Figure No. 1). Located within the UNESCO designated Mount Arrowsmith Biosphere Region, the Winchelsea Islands site was noted by locals to have a flourishing bull kelp forest; however, no bull kelp is found near the site today. Additionally, the Northumberland Channel historically and presently has bull kelp just south of the enhancement plot site.

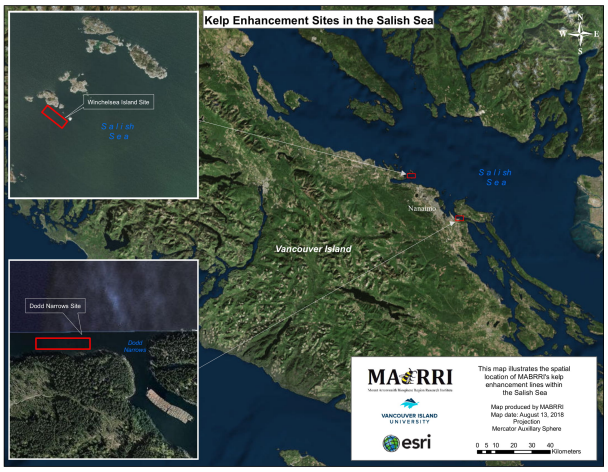


Figure No. 1. Site locations of MABRRI's *Nereocystis luetkeana* enhancement plots in the Strait of Georgia, British Columbia

Site selection for the *N. luetkeana* enhancement plots was based on local historical knowledge that was obtained by speaking with fishermen and divers that have frequented the area for the past 30 years. Through this knowledge sharing, it was noted that bull kelp

has either declined, or is now completely absent in these regions. Additionally, prior to this project, initial surveys were conducted indicating small amounts of *N. luetkeana* near Dodd Narrows. Further, data loggers, measuring temperature and light intensity at the bottom and six metres from the bottom, were deployed at both sites, and initial results indicated favourable characteristics of bull kelp. Both sites were determined to have rocky substrate with suitable depths of approximately 9 meters, and suitable currents that support the growth of *N. luetkeana*.

Methods

Installation of enhancement plots followed Project Watershed's methods, used at their enhancement plots off Hornby Island. The set up included two concrete anchors with a 19mm diameter rope strung between them. Multiple spools of pre-seeded lines, which are strings with *N. luetkeana* growing on them, were wrapped onto the rope as it was lowered (Heath & Chambers, 2014). Additionally, mature *N. luetkeana* were collected and transplanted onto the rope. One of the transplant methods was adapted and modified from a project in Washington State; the other was developed by MABRRI and Heath (Carney, Waaland, Klinger, & Ewing, 2005).

Two methods were employed during the transplant. The first method ("Method A"), involved a piece of nylon cord looped around the stipe of the *N. luetkeana*, just above the holdfast, with the loop being secured by a cable tie. A second loop, on the open end of the nylon cord, was created with a second cable tie, through which the third cable tie was guided to attach to the nylon cord to the rope (Figure No. 2a) (Carney et al., 2005). The second method ("Method B"), involved fastening the holdfast directly onto the rope by wrapping veterinary tape around them. A single cable tie was then attached on either side of the stipe, over top of the veterinary tape, to

secure the holdfast while minimizing abrasion (Figure No. 2b). A total of 12 individual kelp were evenly distributed along the rope, with an even number of each method used at each site. Each kelp was coded and tagged to easily monitor each kelp's individual progress.

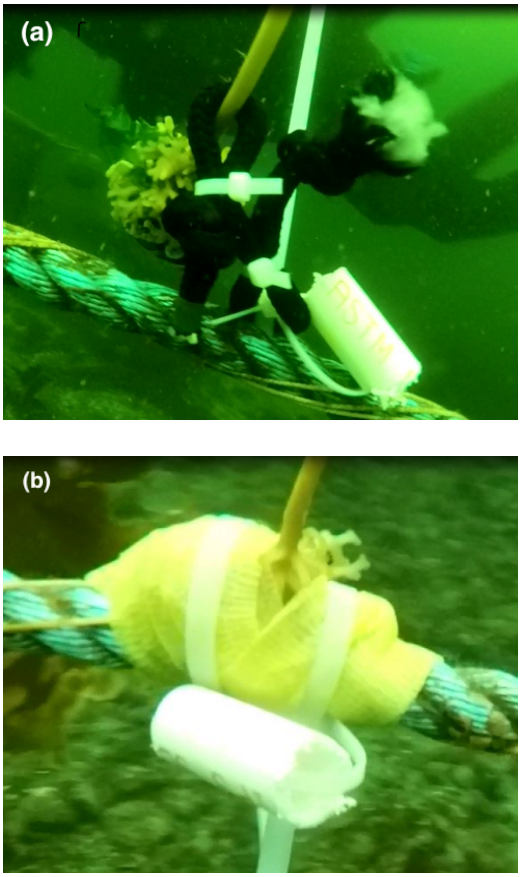


Figure No. 2. The two methods used to attach mature *Nereocystis luetkeana* sporophytes to the enhancement plot rope.

Preliminary Results

The transplant of all mature *N. luetkeana* sporophytes occurred on June 6, 2018. By August 16, 2018, seven individuals remained between both sites; four individuals that were attached via Method A, and three individuals that were attached via Method B. The individuals that did not survive either snapped along their stipe, were grazed, or were completely absent from the site. Five individuals were observed to have sori over the summer, and we will continue to monitor for new sporophyte production occurring at both sites.

Using a time-lapse camera and periodic observations from divers, species that were commonly observed using the *N. luetkeana* as habitat were schools of Pacific herring *(Clupea pallasii)*, schools of shiner perch *(Cymatogaster aggregate)*, and juvenile copper rockfish *(Sebastes caurinus)*. Our dive team is also surveying the benthic species present near the enhancement plots, recording wheth-

er changes are occurring to the composition of benthic flora and fauna over time. This surveying is accomplished by using one-meter by one-meter quadrats in pre-determined locations underneath the kelp lines, at both sites.

Next steps

The goal of the enhancement plots is for the *N. luetkeana* to reproduce and form self-sustaining kelp forests within our study sites, as well as provide habitat for species that would normally use these kelp beds as habitat. In addition to the efforts of restoring *N. luetkeana*, baseline data regarding water parameters and species composition at each site is being collected. This data may then be used to assist future projects in understanding how bull kelp is being impacted over time by changing environmental and climatic conditions.

References

Carney, L. T., J.R. Waaland, T. Klinger, and K. Ewing. 2005. Restoration of the bull kelp Nereocystis luetkeana in nearshore rocky habitats. Marine Ecology Progress Series. 302: 49-61.

Heath, W., and K. Chambers. 2014. Bull kelp restoration project at Hornby Island, BC, Canada. Salish Sea Ecosystem Conference. 18.

Heath, W., R. Zielinski and A. Zielinski. 2017. 2017 Technical report on restoration research on kelp forest habitats in the Salish Sea. Report submitted to Pacific Salmon Foundation, Salish Sea Marine Survival Project. 48 pp.

Lamb, A., D. Gibbs and C. Gibbs. 2011. Strait of Georgia biodiversity in relation to bull kelp abundance. Pacific Fisheries Resource Council. 111 pp.

Lindop, A. (2017). Seaweeds: Giant kelp and bull kelp. Oceanwise. 13.

The Status, Drivers, and Impacts of Poaching in Lake Chilwa Biosphere Reserve

Patrick Zakeyo
Department of Environmental Science, Egerton University
Department of Fisheries, Lilongwe, Malawi

Paul Makenzi
Department of Environmental Science, Egerton University

Marlene Chikuni
Department of Biological Sciences, Chancellor College, University of Malawi

AUTHOR ADDRESS
Patrick Zakeyo
Department of Fisheries, P.O. Box 536, Lilongwe, Malawi
Email: zakeyop@gmail.com

ABSTRACT: An assessment of the status, drivers, and impacts of poaching was conducted in the Lake Chilwa Biosphere Reserve (LCBR) in Malawi. One hundred households from which primary data was collected were sampled using systematic random sampling. Secondary data was collected from fisheries and agriculture departments, and the biosphere reserve manager. The results of the study indicate that poaching in the LCBR exists, and its level of frequency is high, as indicated by 61.3 percent of respondents, and the annual licensing of <5 percent of tools. The main drivers of poaching are poverty, food

insecurity, population growth, low level of education, and unemployment. Poaching is causing a decline in fish catches, reduction in composition of both birds and fish species, and size of fish caught. There is also a reduction of income in the area, as well as an increase in malnutrition, due to lack of cheap protein sources. The Malawi government should put up policy framework that will create a good environment for small businesses to thrive, improve the livelihood of communities, and eliminate the exploitation of resources from the biosphere reserve. Deliberate policies must be enacted to provide sustainable alternative protein sources.

Keywords: Poaching, Fish, Birds, Impacts, Drivers, Lake Chilwa

Introduction

Poaching is a term that carries a variety of definitions, dependent on the context and individual. In common terms, for convenience and consistency, Carter et al. (2017) adopted the definition of poaching as the illegal killing or taking of wildlife. In this context, it refers to hunting without license or permit in protected areas (National parks, game reserves), using illegal equipment or tools, and any other hunting practices that are against legal provision of any institution or country. Poaching is a problem where wildlife meat is valued as a source of both income and protein (Wilfred and Maccoll, 2015). Wildlife meat is any non-domesticated terrestrial mammals, birds, reptiles, and amphibians harvested for consumption (Nasi et al*.,* 2008). Brashares et al. (2004) reported that the intensity of hunting in Africa is usually inversely related to time spent on agricultural activities. The presence and importance of factors behind wildlife exploitation differ from place to place, and the strategies employed to address problems related to poaching cannot be universal.

Human pressure on wildlife in protected areas is increasing. This is partially due to wildlife being driven off from their habitats as land is converted for settlements and agricultural use. Illegal wildlife use is usually related to the distance between human settlements and protected areas. For example, in the Serengeti of Tanzania, both wildlife meat poaching and consumption rates are quite high among the villages near protected areas (Hofer et al., 1996).

Biosphere reserves are established in hopes of preserving both cultural and natural heritage, in accordance with sustainable development (Sonali, 2017). These reserves include unique areas of the world's biomes, whose selection has been greatly facilitated by a thorough knowledge of the important biotic communities. According to Ratika (2013), biosphere reserves conserve genetic resources, species, ecosystems, and landscapes, without uprooting inhabitants. Biosphere reserves are models for co-existence between nature and human, and provide significant information for scientific studies and research.

Lake Chilwa Biosphere Reserve in Malawi has a variety of birds, fish, and small animal species, that are used for food by a large proportion of the local community (Bhima, 2006). In the area, poaching is considered a key component of the socio-economic framework of people's livelihood. Population increase, poverty, and food insecurity are some of the factors that can influence poaching levels.

Hunting of birds and fishing in the Lake Chilwa wetland of Malawi has taken place for many years, ultimately developing into a significant socio-economic activity. The practice supports a variety of groups of people, both nutritionally and economically. In recent years, the pressure on the wildlife has been increasing due to higher populations, and illegal and unsustainable hunting practices. This has become a threat to the sustainability of

fish, birds, and other wildlife species in this unique ecosystem. Though poaching is a common practice in the Lake Chilwa wetland, there has been no research on status of poaching within the biosphere, and its drivers and impacts caused are not known. Such information is crucial for decision making, considering the LCBR has no legal protection status, despite being a wetland of national importance.

This study sought to assess the status of poaching, driver forces, and its impact on birds and fisheries within the Lake Chilwa Biosphere Reserve. It is through the understanding of the status, drivers, and impacts that we generate information, and can incorporate these findings into existing and new legislations to help eradicate the vice in the management of resources by the relevant authorities.

Methodology

Lake Chilwa Biosphere Reserve and its wetland ecosystem lies in three districts: Machinga, Zomba, and Phalombe. It also lies between the two countries of Malawi and Mozambique.

Lake Chilwa Biosphere Reserve is located in the Southern region of the Republic of Malawi, on the country's eastern border with Mozambique, between latitude 15°00'S and 15°30'S, and longitudes 35°30′E and 35°55′E (EAD, 2001). The biosphere reserve comprises of the lake, typha swamps, marshes, and seasonally inundated grassland floodplain, in which the transition, buffer, and core zones are located. The hydrology of the wetland is an important control on the ecology of the biosphere reserve, determining not only the water chemistry and physical properties, but also the composition of the vegetation and soil characteristics (Howard and Walker, 1974). The area has a tropical climate, that is relatively dry and strongly seasonal (British Geological Survey, 2004).

The Lake Chilwa Biosphere Reserve has a high population, with a density of 164/ km^2 and 1 700 452 in the entire Lake Chilwa basin (EAD, 2001). In 2008, the estimated number of households in the area was 347 300 (NSO, 2008). In an economy dominated by agriculture, individual maize production is one of the key occupations in the area, while tobacco is cultivated as the leading cash crop. Small and medium-scale businesses dominate the area's non agro-based economy, with general retail accounting for the gross of sales (Ludaka, 1991).

Lake Chilwa continues to be the main source of fish in the area, with an annual catch of more than 5 000 tons (Njaya, 2001). Lake Chilwa Biosphere Reserve also hosts a variety of bird species, including some that are migratory (Bhima, 2006). It is estimated that 164 bird species are associated with the area, of which 41 are Palearctic and 14 intra-African.

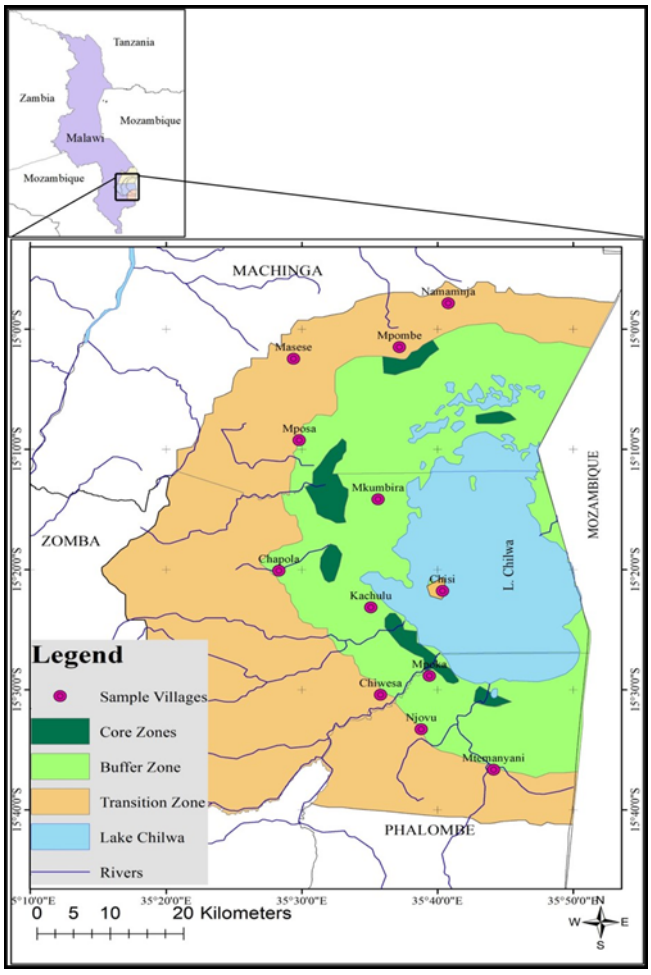


Figure No. 1: Map of the study area.

This study employed a social survey research design, in which semi-structured questionnaires were used to interview sampled households in communities around Lake Chilwa, and key informants in different government sectors. The target population for the study was the community members living within the transition zone of the LCBR. The targeted

community comprised of 347 300 households.

The formula below, by Nassiuma (2000), was used to determine the appropriate number of households that were sampled from the Lake Chilwa Biosphere Reserve.

$$n = \frac{NC^2}{C^2+(N-1)e^2} \quad \text{(Nassiuma, 2000)}$$

In the formula above; n represents sample size; N represents the population size of 347 300 households; C represent coefficient of variation, ≤ 30 percent; and *e* represents margin of error, which is fixed between 2-5 percent. The sample was calculated at 30 percent coefficient of variation, and 3 percent margin of error.

$$n = \frac{347300 \times 30^2}{30^2 + (347300 - 1)3^2} = 99.97 \approx 100$$

Table No. 1. Number of households sampled

District	Target Households	Sampled Households
Machinga	113 683	34
Zomba	158 563	45
Phalombe	75 054	21
Total	347 300	100

Primary data was collected through administration of questionnaires and focused group discussions. Secondary data was collected from documented information in government departments and institutions, and included fisheries and agriculture, and the Biosphere Reserve Manager.

Results and Discussion

The status of poaching

The survey results indicate that poaching occurs in the LCBR, as reported by respondents. The existence of poaching in the LCBR was supported by 88 percent of those surveyed. Respondents who acknowledged the existence of poaching, classified its prevalence as follows (Figure No. 2): 61.3 percent high, 30.7 percent medium, 5.7 percent very high, and only 2.3 percent indicated low levels of poaching. The respondents also indicated that poaching occurs at higher levels on fish, rather than birds.

There are three key reasons for the popularity of poaching in the area. Firstly, it is due to easy access to the buffer and core zones of the LCBR. Secondly, the increase in number of people in the area, resulting in corresponding increase in number of people fishing and hunting. This could also result from fishing being one of the community's major sources of subsistence, second only to farming.

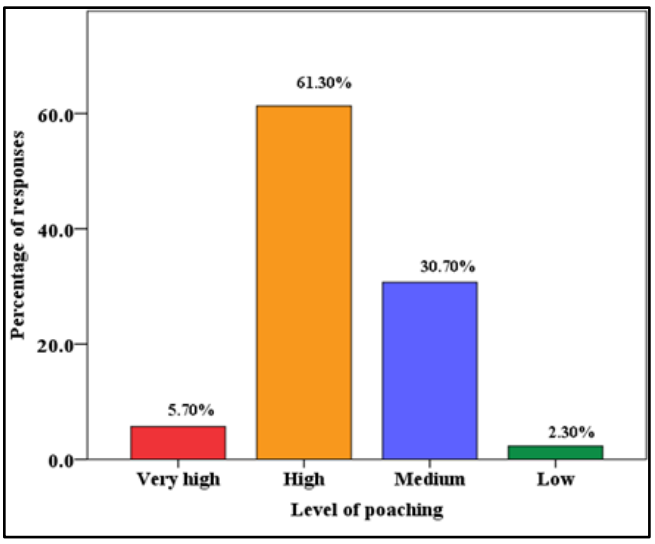


Figure No. 2: Level of poaching in LCBR

Fish is the main source of protein, as it is relatively cheap to obtain in comparison to other livestock, such as goats, poultry, and cattle. Bird hunting is mostly intensified when fish catches no longer meet demand but is otherwise only practiced by a few people in the community. An assessment on the status of biodiversity and threats in Malawi by Millington and Kaferawanthu (2005), revealed that hunting of wildfowl in LCBR has been practiced for some time, but its exploitation increased in 1996, following the drying up of the lake and the collapse of the fishery in 1995.

Poaching levels were also indicated by the trends in licensing of fishing tools. An assessment on the number of fishing tools licensed on annual basis between 2014 and 2017, as shown in Table No. 2 and Figure No. 3, indicate that less than 5 percent of the total recorded fishing tools are licensed annually. This implies high levels of poaching, as it is in contravention of the fisheries regulations.

Table No. 2: Percentage of licensed fishing tools from 2014 to 2017

Year	2014	2015	2016	2017
Estimated tools	74078	82393	37950	-
Licensed tools	48	192	742	23
Percentage licensed	0.06	0.23	1.95	-

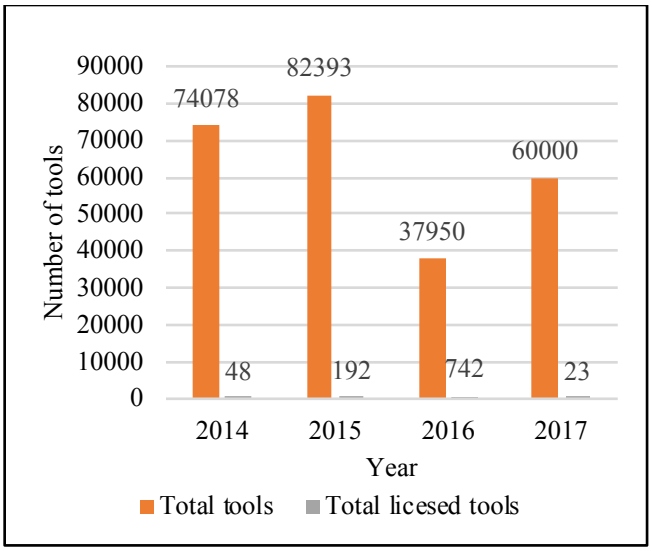


Figure No. 3: Total number fishing tool and total licensed tools

Other indicators of poaching

In the LCBR there was an overall increase in trend of the number of people engaged in fishing between 2008 and 2016 ($r^2 = 0.0711$; $y = 4357+140t$) (Figure No. 4). The reduction in numbers of fishermen between 2011 & 2012 coincides with the period in which Lake Chilwa dried up and the fishery collapsed. The general increase in the trend indicates the possibility of an increase in poaching on fisheries resources.

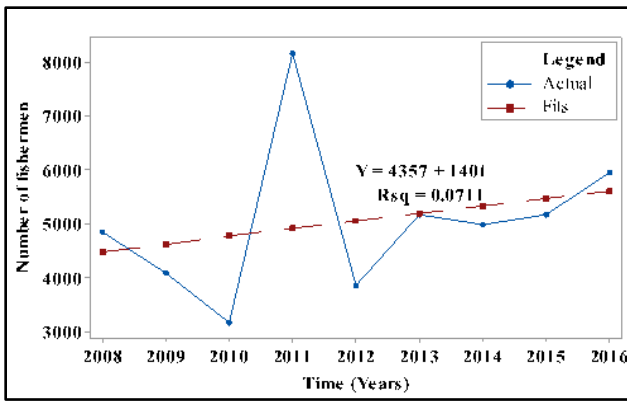


Figure No. 4: Numbers of fishermen from 2008 to 2016

A variety of tools are used for fishing in the LCBR, including gillnets, fish traps, seine nets and lines, and hooks. Many of these tools are modified in violation of the government's prescribed regulations (e.g. mesh size and net material). There has been a general increase in the number of different fishing tools over the years (Figure No. 5), which are rarely licensed, as per the government requirements (Table No. 2). This increase has been brought on by a growth in the number of local fishermen. This further indicates that most of the people involved in fishing activities do so illegally, as they do not have the permit to do so.

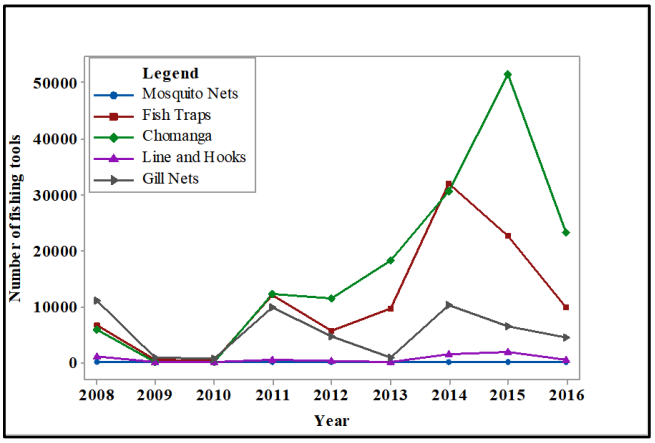


Figure No. 5: Trends of fishing tools in Lake Chilwa from 2008 to 2016

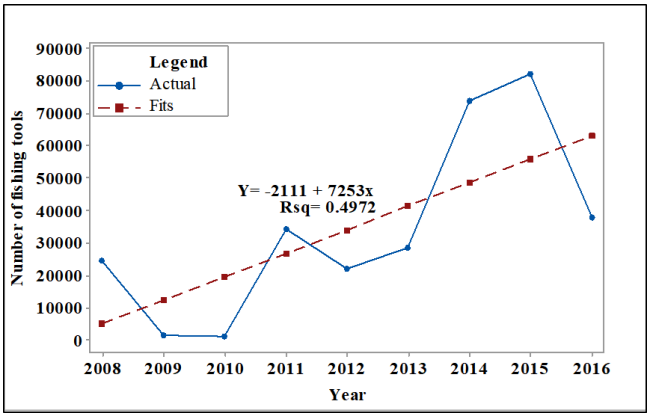


Figure No. 6: Trend of annual total number of fishing tools in the LCBR from 2008 to 2016

The trend of the total number of all fishing tools has been significantly rising (r^2 = 0.4972; y = -2111+7253x, $p < 0.05$) (figure 6). In addition, some fishermen clear vegetation in the lake, such as the *Typha dominguensis* (*mjedza*) and *Aeschynomene pfundii*, to make it easier to catch higher quantities of fish. Such practices result in the destruction of habitats for both fish and bird species. The vegetation provides a natural sanctuary—a secure breeding and hiding spot for fish—and also serves as sites for bird nests. The removal of such vegetation is an illegal practice, as per fisheries regulations.

Drivers of poaching

The driving forces of poaching in the LCBR are the need of food and income, and, to a smaller extent, employment and the protection of crops. Poaching as a means of food and income account for 48 percent and 48 percent, respectively. Employment and the protection of crop fields only accounts for a combined total of 4 percent. Community members are mostly engaged in poaching for sustenance, in both nutritional and economical senses of the word. However, it was indicated that poverty, lack of enough food, population growth, inadequate enforcement resources, low education levels, and unemployment drive poaching to higher levels (Figure No. 7).

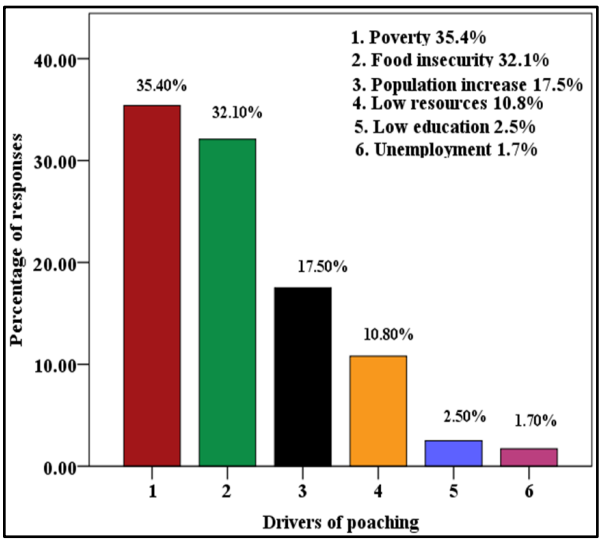


Figure No. 7: Drivers of poaching in the LCBR

Table No. 3: Level of income and involvement in fishing and bird hunting in the LCBR

Daily Income	Fishing and Bird Hunting		Overall (%)	□²
	Not involved (%)	Directly involved (%)		
Below $1.90 /day	66.7	67.3	67	0.005
Above $1.90 /day	33.3	32.7	33	
Total	100	100	100	

The results show that 67.3 percent of those directly involved in fishing and bird hunting were poor, as opposed to the 32.7 percent who were not poor (Table No. 3). Though the findings show that poverty drives illegal fishing and bird hunting, the results indicate that there is no association between income level and involvement in the activity (X^2 (1) >= 0.005, p = 0.946). This is because those with high income have the capacity to procure efficient fishing and hunting tools, as opposed to the poor who must resort to more traditional fishing and hunting methods.

Malawi is one of the poorest countries in the world, with 50.7 percent of the population living below the poverty line (IMF, 2017), receiving approximately $1.90 per day. The population of the Lake Chilwa wetland is no different, and people depend on fishing to earn an income. The report by CITES Secretariat et al., 2013, discloses that sites with communities experiencing higher levels of poverty, will also have higher levels of poaching. However, in their review, Duffy and St. Johns (2013) found that, though poverty may motivate people to poach, members of poor

communities would not engage in the poaching of commercially valuable species, unless there was demand from wealthier communities. Individuals in the LCBR mostly practice subsistence type of poaching. The primary purpose for this kind of poaching, is food, and, in the process, supports local trade, as not all can be fishermen.

Table No. 4: Level of education and involvement in fishing and bird hunting in the LCBR

Education Level	Fishing and Bird Hunting		Overall (%)	χ^2
	Not involved (%)	Directly involved (%)		
Primary	41.02	65.6	56	6.099*
Secondary	53.85	32.8	41	
Tertiary	5.13	1.6	3	
Total	100	100	100	

The results (Table No. 4), show that 56 percent of the respondents only attained primary education, thus indicating that most individuals in the biosphere reserve are not highly educated, and lack the credentials required for employed in the formal sector. The results also show that 65.6 percent and 32.8 percent of those directly involved in fishing and bird hunting attained primary and secondary education, respectively, and only 1.6 percent attained tertiary level. There is a significant association between level of education and direct involvement in fishing and bird hunting in LCBR (X^2 (2) = 6.099, $p < 0.05$). In Malawi, unemployment rates are very high. Many people remain idle due to a lack of skills and experience required in the labor force. It is also a fact that many uneducated people are involved in illegal hunting, simply because

they don't understand the importance and benefits of wildlife resources.

Table No. 5: Food security status and involvement in fishing and bird hunting

Food security status	Fishing and Bird Hunting		Overall (%)	□²
	Not involved (%)	Directly involved (%)		
Food Insecure HH	46.2	70.5	61	5.923*
Food Secure HH	53.8	29.5	39	
Total	100	100	100	

The results (Table No. 5) show that 70.5 percent of those involved in fishing and bird hunting are food insecure, whereas 29.5 percent are food secure. Food security level in the LCBR significantly influences the involvement of individuals in fishing and bird hunting activities (X^2 (1) = 5.923, $p < 0.05$). In addition, food insecurity has been indicated as one of the key drivers of poaching (figure 7). According to World Summit on Food Security 1996, food security exists when all people, at all times, have physical, social, and economical access to sufficient, safe, and nutritious food, adequately meeting their dietary needs and food preferences. In recent years, adverse effects of climate change, e.g. drought, have led to loss of yields, thereby forcing people to seek alternative sources of food. Natural resources, such as fish and birds, are prone to exploitation when they are open access. Such is the case in the LCBR. These findings coincide with the findings of Kafumbata et al. (2014). In their report, they noted that African inland lakes, such as Lake Chilwa, contribute significantly to food security and livelihoods through direct exploita-

tion of fisheries resources. However, they stated that the ecosystem services provided are under significant stress, mainly owing to the high demands of an increasing population, negative anthropogenic impacts on lake catchments, and high levels of poverty, resulting in unsustainable use.

With the increase in population, farmable land is becoming smaller, resulting in low food production. GOM and World Bank (2006) found that the average landholding size per household in Malawi is 1.2 hectares, while the average land per capita is 0.33 hectares, leading to low agriculture production whilst the population grows. The report by CITES Secretariat et al. (2013), supports the reports that poaching levels decrease as food security increases.

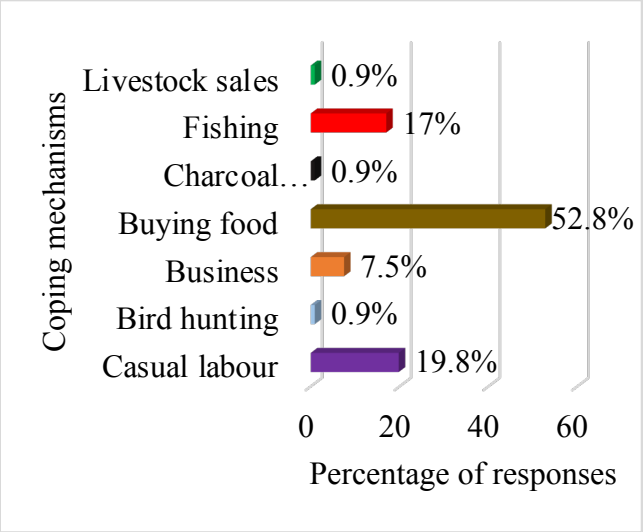


Figure No. 8: Coping mechanisms during food shortage

Fishing is one of the major coping mechanisms used by people in times of food shortage (Figure No. 8). This indicates that some people are driven into fishing activities due to a lack of food. It has also been shown that the fishing and hunting of birds are often ways for individuals to support their families.

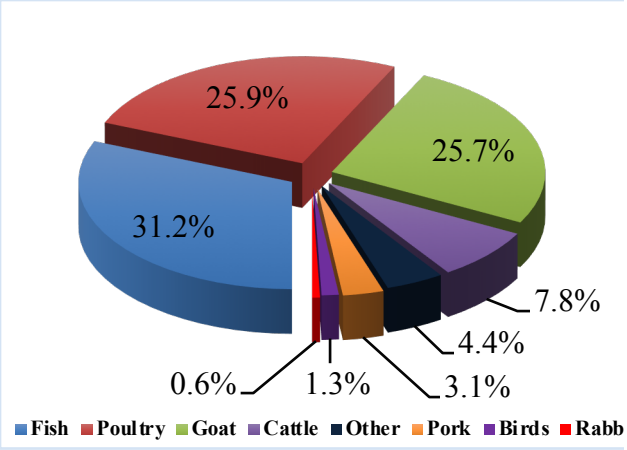


Figure No. 9: Identified protein Sources for communities

Fish is also one of the major animal proteins to the people in the LCBR, as indicated by 31.2 percent of respondents (Figure No. 9). This is because it is readily available and cheaper than other animal protein sources. Lake Chilwa is an open access resource and easily accessible by everyone, making illegal fishing and bird hunting an easy option for people during times of food shortage. Many people depend on natural resources for food during difficult times. In their study, Chiotha et al. (2017) reported that bird hunting intensifies from November to February in the LCBR, a period when most households experience seasonal food shortages. These indicators show the link between food security status and an increase in poaching levels in the LCBR. According to Fa (2000), intensive farming of livestock and other forms of domestic protein is the only way to provide a sustainable source of food. However, Brown and Williams (2003) argue that the capital for livestock rearing is too restrictive for smallholder farmers. Therefore, this condition makes it difficult for most individuals to stop relying on natural resources for food and other amenities, because most of them are openly accessible, and simple, inexpensive tools are used to kill them. This results in a high return for little investment.

The impacts of poaching

Poaching has been causing devastating impacts to both the biosphere resources (fish and birds) and people's livelihood in the Lake Chilwa Biosphere Reserve. In Figure No. 10, 28 percent of the respondents indicated that

there was reduction in fish catches, followed by 27 percent reduction in sources of cheap protein, and 21, 11, 5, 4, 3, and 1 percent indicating reduction in income for the people and species, variability of bird species, reduction size of fish caught over time, increased malnutrition, and non-existence of some fish species respectively.

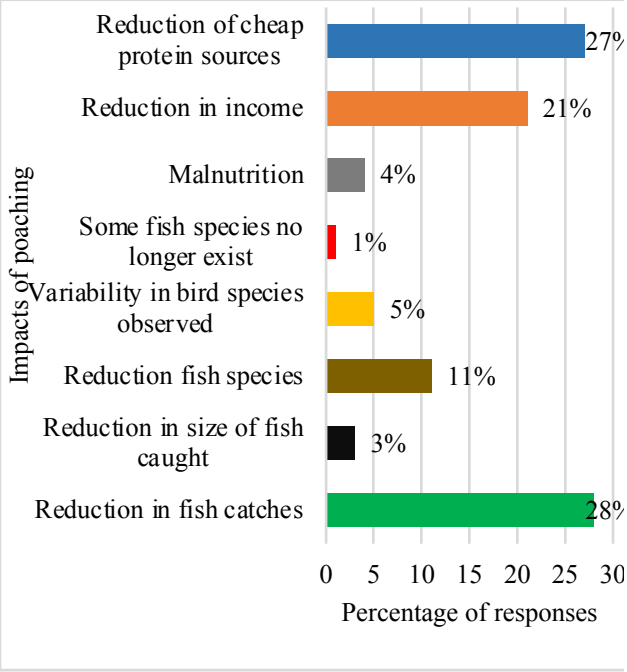


Figure No. 10: Results on observed impacts of poaching

The impact of poaching in the biosphere reserve on species is manifested through a reduction in fish catches. It is reported that in the past, the lake had a variety of fish species. In recent year, however, only a few species are found, and the fish population is currently dominated by catfish (*Clarias gariepinus*), tilapia (*Oreochromis shiranus chilwae)*, and barbus species (*Barbus paludinosus*). This shift indicates that the number of fish species has significantly diminished; a stark contrast to years before. Figure No. 11 shows the decline in species diversity between 2008 and 2017 The trend shows an actual reduction in catches of most of the species. The trend in Figure No. 12 shows that there has been a steady reduction of catches of all fish species over the course of ten years ($r^2 = 0.1576$, $y = -485t + 9173$).

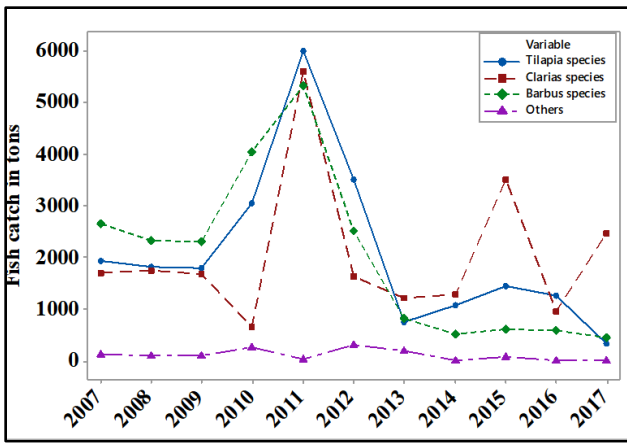


Figure No. 11: Trend of fish catches in the LCBR from 2007 to 2017

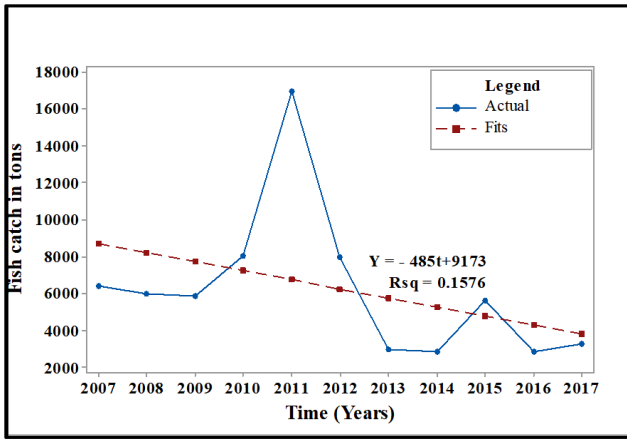


Figure No. 12: Trend of total annual fish caught between 2007 and 2017

In Figure No. 13, the total number of birds killed/trapped over the years shows a general increase between 2009 and 2012, and a decline between 2012 and 2013, indicating the trend is somehow dynamic. The trend's line shows a gentle increase in number of birds killed, though not significant (r^2=0.0088, y = 321+10.3).

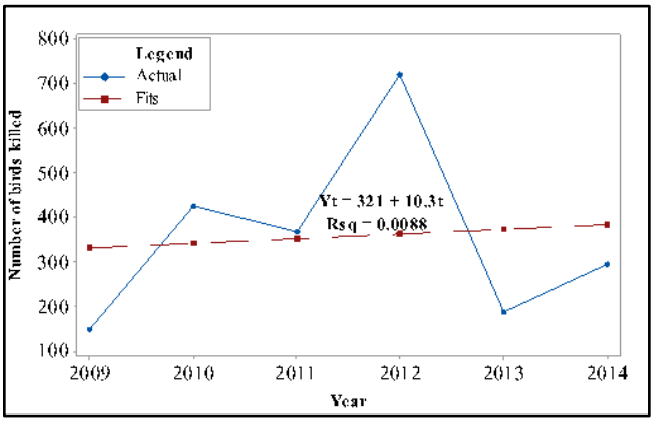


Figure No. 13: Trend of birds trapped between 2009 and 2014

The slight increase in number of birds trapped is attributed to high levels of poaching, confirming that people continue to exploit birds, thus threatening them with extinction. Birds are poached for both consumption and income. The collapse of the fishery due to overfishing and frequent lake recessions has resulted in the need for an alternative source of livelihood: the hunting of many bird species. The major bird species most targeted include Fulvous whistling ducks (*Dendrocygna bicol-*

or), white-faced whistling ducks (*Dendrocygna viduata)*, Lesser Moorhen (*Gallinula angulata),* Lesser Gallinula (*Gallinula alleni*), Crested francolin (*Dendroperdix sephaena*), Lesser masked weaver (*Ploceus intermedius*), and Spur-winged goose (*Plectropterus gambensis)*. However, there is paucity of data indicating the number of birds killed per species, as well as the amount of birds that have been caught in the past, due to a lack of documentation.

In this study, poaching has been implicated as the main cause of reduction in quantities and size of fish caught, reduction in variety of fish species caught, seasonal variability in bird species observed and trapped, and inexistence of some species. The respondents also indicated that these changes could not be entirely attributed to poaching alone, but also the effects of climate change, poor farming practices, and destruction of habitats. Climate change in the area has been evidenced by fluctuating water levels in the lake. This affects availability of water in the lake, thereby impacting breeding and habitat of fish and bird species. Climate change is also affecting crop production in the area, leading to poor harvests for the community, and ultimately driving people to rely on the natural resources within the biosphere reserve, for both food and income. It has been reported that some people depend solely on the resources of the LCBR for livelihood.

Funding Sources

This work was supported by the United States Agency for International Development as part of the Feed the Future initiative, under the CGIAR Fund, and the predecessor fund, the Food Security and Crisis Mitigation II. Part of this work was also supported by the German Federal Agency for Nature Conservation (BfN) through Biosphere Reserves as Models for Anti-Poaching in Africa (BRAPA) project, implemented by the African Wildlife Foundation.

ACKNOWLEDGMENT

I wish to sincerely thank Dr. Paul Makenzi and Dr. Marlene Chikuni for their input in this work. I wish to acknowledge the communities living around Lake Chilwa, the fishermen committees and the Malawi government agencies, especially the fisheries and agriculture departments for their invaluable support, and for providing all data needed during my research work.

REFERENCES

Bhima, R. (2006). Subsistence Use of Waterbirds at Lake Chilwa, Malawi. *Waterbirds Around the World*, 255-256.

Brashares, J.S., Arcese, P., Sam, M.K., Coppolillo, P.B., Sinclair, A.R., Balmford, A. (2004). Bush Meat Hunting, Wildlife Declines and Fish Supply in West Africa. *Journal of Science, 306*, 1180-1183.

British Geological Survey. (2004). *Ground Water Quality.* National British Research council.

Brown, D. and Williams, A. (2003). The case for Bushmeat as a Component of Development Policy: Issues and Challenges. *International Forestry Review* , 5(2):148-155).

Carter, N. H., López-Bao, J. V., Bruskotter, J. T., Gore, M., Chapron, G., Johnson, A., and Treves, A. (2017). A conceptual Framework for Understanding IllegagalKilling of Large Carnivores. *46*, 251-264.

Chiotha, S.S., Likongwe, P.J., Sagona, W., Mphepo, G.Y., Likoswe, M. Tsirizeni, M.D., Chijere, A. and Mwanza, P. (2017). *Lake Chilwa Basin Climate Change Adaptation Programme: Impact 2010 – 2017. LEAD SEA Publications.* Zomba, Malawi.

CITES Secretariat, IUCN SSC African Elephant Specialist Group and TRAFFIC International. (2013). *CITES Secretariat, IUCN SSC African Elephant Specialist Group andStatus of African Elephant Populations and Levels of Illegal Killing and the Illegal Trade in Ivory: A Report to the African Elephant Summit.* CITES, IUCN and TRAFFIC International.

Duffy, R and St John, F.A.V. (2013). *Poverty, Poaching and Trafficking: What are the links.* Evidence on Demand.

Environmental Affairs Department (EAD). (2001). *Lake Chilwa Wetland Management Plan. Ministry of Natural Resorces and Environmental Affairs* . Lilongwe: Malawi Government.

Fa, J. E. (2000). Hunting animals in Bioko, West Africa. (J. G. Robinson, Ed.) *Sustainability and Future Hunting for Sustainability in Tropical Forests*, 168-198.

GOM and World Bank. (2006). *Malawi Poverty and Vulnerability Assessment: Investing in Our Future.* Lilongwe: Ministry of Economic Planning and Development.

Hofer, H.,Campbell, K.L.I., East, M.L., Huish, S.A. (1996). The impact of game meat hunting on on target and non target species in the Serengeti. *The Exploitation of Mammal Population*.

Howard-Williams, C. and Walker, B.H. (1974). The vegetation of a tropical African Lake: Classification and Ordination of the Vegetation of Lake Chilwa, Malawi. *The journal of Ecology*, 831-854.

IMF. (2017). *Malawi Economic Development Document.* Washington DC: International Monetary Fund Publication Services.

Kafumbata D., Jamu, D., and Chiotha, S. (2014). Riparian Ecosystem Resilience and Livelihood Strategies Under Test: Lessons from Lake Chilwa in Malawi and other Lakes in Africa. *Philosophical Transactions ot the Royal Society. B 369: 20130052*.

Ludaka, G. (1991). *Socio-economic Impact Assessment of the Namasalima-Nkuba Road on the Wood Business ad Fishing Industry at Nkuba Fish Landing Site.* Sociology Department. Zomba: University of Malawi.

Millington, S. J. and Kaferawanthu, M. (2005). *Analysis of Biodiversity Threats and Opportunities in Malawi: Assessment of Current Status.* Occasional Paper No.13, Malawi CompassII.

Nasi, R., Brown, D., Wilkie, D., Bennett, E., Tutin, C., van ToL G. and Christophersen, T. (2008). Conservation and Use of WildlifeBased Resources: The Bushmeat Crisis. Secretariat of The Convention on Biology Diversity, Montreal and Center For International Forestry Research: (CIFOR),Bogor.CBD Technical Series No.33.

Nassiuma, D. (2000). *Survey Sampling: Theory and Methods.* Njoro: Egerton University Press.

National Statistical Office. (2008). *The 2008 Population and Housing Census* . Zomba, Malawi: National Statistical Office.

Njaya, F. (2001). *Review of Management Measures for Lake Chilwa, Malawi.* Fisheries Training Programme, United Nations University.

Ratika, G. (2013). *https://www.meritnation.com/ask-answer/question/what-is-the* . Retrieved from https://www.meritnation.com.

Sonali, N. (2017). *http://www.biologydiscussion.com/essay/biosphere-reserve-*. Retrieved from http://www.biologydiscussion.com.

Wilfred, P. and Maccoll, A. (2015). Local Perspective on Factors Influencing the Extent of Wildlife Poaching for Bushmeat in a Game Reserve in Western. *International journal of conservation science, 6*(1),

99-110. Retrieved from http://www.ijcs.uaic.ro/public/IJCS-15-10_Wilfre