

DISASTER AND HEALTH VULNERABILITY ASSESSMENT FOR THE POPULATION OF THE KINGDOM OF BHUTAN

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ABSTRACT

Bhutan has reached medium level of human development. This and other factors make it prone to the negative impacts of climate change, flooding, droughts and epidemics. The government of Bhutan has participated in regional initiatives aimed at dealing with vulnerability to floods and droughts. However, some dimensions of the country's and population's vulnerability have not been studied yet. Therefore, a combination of literature review and calculations was used to assess the health, WASH and socio-economic dimensions of vulnerability of the Bhutanese population. Results of the review indicate that the government of Bhutan has initiated programmes with focus on the health outcomes of climate change and on universal access to healthcare. Critical efforts have focused on the compilation of the essential medicines' list and targeting the risk factors of non-communicable diseases such as alcohol abuse. By 2013, 95 % of the Kingdom's population had access to a healthcare facility within three hours walking distance from their dwelling and the main avenue of access is through government facilities. From 2008 to 2013, the expanded medical infrastructure vulnerability index ranged from 1.858 to 2.420 per 1000 inhabitants/citizens between 2008 and 2013, i.e. Bhutan achieved the World Health Organisation target of 2.3 healthcare professionals per 1000 inhabitants. The WASH vulnerability criterion decreased from 0.241 in 2000 to 0.128 in 2013. There was a strong correlation between the WASH vulnerability of the Bhutanese population and its economic/social vulnerability at 5 % level of significance (p -value = 1.2×10^{-5} and 7.06×10^{-4} , respectively). Such correlations can be used as a guide for policy development, adaptation and development for further vulnerability decrease in the Kingdom of Bhutan.

Keywords: social vulnerability, economic vulnerability, WASH vulnerability index.

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The Kingdom of Bhutan is a small land-locked country in Southeast Asia (Statistical Yearbook of Bhutan [SYBB], 2014). The country's climate varies with geographical location, but can be split into three main zones, namely "alpine, temperate and sub-tropical" (SYBB, 2014, p. XVI). Bhutan's economy is strongly dependent on agriculture (Tusneem, 2011). The kingdom's population has increased from 634,000 in 2004 to 754,000 in 2013 (WHO, 2014a) and is predicted to reach 886,523 by 2030 (Bhutan National Development Report, 2013). These figures translate to an average population growth rate of between 1.6 and 1.9 % per annum. The country's human development index reached 0.595 in 2012 (UN, 2016). This translates to a lower medium level of development and indicates a high degree of climate hazard vulnerability (Chalise, Shrestha, M.L., Budhathoki, & Shrestha. M.S, 2005; Ehrlich, Kareiva & Daily 2012).

The climate change and geographical location of Bhutan places its population centres, lifelines and assets at risk from various disasters and hazards (Ahmad, 2004; Chalise et al., 2005; Tiraboschi, 2015). Rainfall patterns in the geographical area of Bhutan and neighbouring countries have been changing recently. The total volume of precipitation remains constant, but it is delivered over short periods of time in a given year (Sivakumar & Stefanski, 2011, p. 18), i.e. increasing the probability of flooding. Flooding can, in turn, result in reduced volumes of drinking/potable water that are available for human consumption and agricultural uses (Katel, Schmidt-Vogt, & Dendup 2015; WHO, 2017a). Insufficient volumes of available drinking water can result in the spread of epidemics related to water, sanitation and hygiene (WASH) that can be compromised during flooding (UNICEF, 2012). This is a public health problem as the territory of Bhutan is prone to epidemics (Wilks, Farrington, & Rubinstein 2003; Umaru et al., 2013). As 10-15 % of morbidity cases in Bhutan originate from diarrhoeal diseases (WHO, 2017a), inferior WASH conditions in the country can create a dire disaster management/public health situation.

Agriculture has long been the backbone of the economic activity in the Kingdom of Bhutan. In 2008, the GDP of Bhutan grew by 21.4 % but the relative significance of the agricultural sector to the economy is set to decline over time (Sivakumar & Stefanski, 2011). However, the sector still employs a significant portion of the Bhutanese population (Sivakumar & Stefanski, 2011). Also, worth noting is that the food security of the population depends on subsistence farming, which often occurs on small holdings that are located on steep slopes and in disaster-prone parts of the country (UNDP/GEF/RGOB,

2004). Droughts in the South Asia/Southeast Asia regions have become longer and more severe in the last twenty years in comparison to the previous periods (Sivakumar & Stefanski, 2011, p. 18). Significant to note is that such a change can have a negative effect on economic activities and food security/vulnerability of the Bhutanese population. This means that water stress and disasters have the potential to decrease agricultural production in the Kingdom of Bhutan (UNDP/GEF/RBOG, 2004). A decrease in the water availability for irrigation/agricultural purposes could become a compounding factor in terms of disaster vulnerability and nutritional status of the Bhutanese population.

Cooperation between the Kingdom of Bhutan and its neighbour states has been suggested in a bid to reduce and manage disaster risk in the region (Aziz & Paul, 2015). Such a cooperation should be aimed at addressing the disaster risk management priorities, e.g. the collection of essential data on all variables that influence disaster risk (SEARO/WHO, 2006). This places critical importance on the availability of the data which can be used to assess and quantify disaster risk, hazards, vulnerability, exposure, resilience and preparedness (Tandlich Hoossein, Whittington-Jones, & Moyo, 2013a). Data from the two sub-regions of Asia are of significance to Bhutan. Some organisations such as the World Health Organisation (WHO) locate the Kingdom of Bhutan in the Southeast Asia region, while geographical and climate change literature often states that Bhutan is part of South Asia (Sivakumar & Stefanski, 2011). Based on the type of data discussed below, references to both Southeast Asia and South Asia will be used where applicable in the current study.

The Kingdom of Bhutan is a member of the Regional Association II (RA II) which is a World Meteorological Organisation (WMO) regional body and its membership includes 33 countries in the Asian and Eurasian regions (Al Mandoos, 2017). As part of this regional body, Bhutan has participated in programmes targeting flood and drought management (Al Mandoos, 2017). At the same time, focus of the RA II has been placed on assisting Bhutan in addressing the following challenges arising from climate change (Al Mandoos, 2017): Public health, data collection and prediction in the areas of meteorology and hydrometeorology. The projects have been ongoing since 2010 with the assistance of Global Environment Facility, WHO, WMO, the United Nations Development Programme and other stakeholders (Al Mandoos, 2017). At the same time, government employees from the Kingdom of Bhutan have participated in workshops on capacity building and

technical skills development in the disaster risk reduction that are run by RA II (Al Mandoos, 2017).

Hales, Kovats, Lloyd and Campbell-Lendrum (2014), estimate that the mean mortality due to climate-related diarrhoea could reach 14,870 total deaths in 2030 and 7,717 in 2050 in Southeast Asia. For the South Asia region, these numbers would reach 765 in 2030 and 383 in 2050 (Hales et al., 2014). Major concerns from the health vulnerability point of view arise from the predicted rates of death due to under-nutrition. In 2030, the numbers were projected to range from 3,348 to 20,692 for the South Asia and Southeast Asia regions (Hales et al., 2014). In 2050, under-nutrition was estimated to result in additional deaths ranging from 3,049 to 16,530 for the South Asian and Southeast Asian regions (Hales et al., 2014). From the vector-borne diseases, dengue will be the causative agent of a limited number of deaths, but the significance of malaria will remain high. This is foreshadowed by the fact that between 287 and 9,343 deaths will be attributable to malaria in South Asia and Southeast Asia in 2030 and 2050, respectively (Hales et al., 2014). According to Hales et al. (2014), heatwaves were expected to account for between 2,408 and 24,632 deaths due to climate change between 2030 and 2050. The above data is useful as it illustrates the regional context in which Bhutan must be seen from the point of view of public health challenges.

Based on the above data, climate change will remain an ongoing disaster challenge in the Kingdom of Bhutan. This essentially means legislation and the disaster management system of the country must contain elements which cover all four stages of the disaster management cycle; i.e., response, recovery, preparedness and mitigation (SEARO/WHO, 2006). Disaster risk management is based on data about disaster hazards, vulnerability, exposure, preparedness and resilience of the population, assets and the country at large (Tandlich et al., 2013a). Such data is critical as it puts in place logistical arrangements for the gathering of resources needed in the disaster risk management in a given country (SEARO/WHO, 2006). Also critically important is that some efforts have been undertaken by the Royal Government of Bhutan to improve disaster resilience against floods (Meenawat & Sovacool, 2012).

Analyses of the flood vulnerability of the Bhutanese population has been conducted (Elalem & Pal, 2015) and indicators of health vulnerability have improved in recent years (Wang et al., 2012). Yet underneath all this, a more detailed analysis of disaster/health vulnerability of the Bhutanese population and its various dimensions is needed. One of the main reasons for additional analysis is premised on the fact that Bhutan is located in one of the

most disaster-prone regions in the world, where climate change will only exacerbate the effects of these disasters in the near future (Sivakumar & Stefanski, 2011). As such, the main objective of this article is to analyse the vulnerability of the Bhutanese population, with specific focus on public health.

Methodology

A combination of literature review and calculations was used to assess the vulnerability of the Bhutanese population. Databases used in the literature review include: GOOGLE SCHOLAR, SCOPUS, WHO and World Bank (WB). The population's health vulnerability will depend on the following variables: The general status of the healthcare system, the WASH situation in the country, the ability of the healthcare system to deal with the number of casualties and fatalities. These aspects of the disaster/health vulnerability in Bhutan can be assessed using the following indicators: The mean life expectancy at birth (Index Mundi, 2016a), the neonatal mortality, the mortality among children under 5 years of age, the government expenditure on healthcare as a percentage of the gross domestic product (GDP) and the rates of vaccination against some preventable infectious diseases among the Bhutanese children. The coverage of the population with improved water and sanitation also plays a significant role. These figures were obtained from the World Health Organization (WHO) sources (WHO, 2014a; WHO 2014b).

During a disaster, the ability of the healthcare system to cope with the human morbidity and mortality can be assessed using the expanded medical infrastructure vulnerability index (*EMIVI*) as defined by Kumpulainen (2006) and later modified by Tandlich et al. (2013b). This is shown in Eq. (1) below.

$$EMIVI = 1000 \times \frac{N(\text{healthcare staff})}{N(\text{population})} \quad (1)$$

In the denominator of Eq. (1), the term *N* (population) represents the total population of the Kingdom of Bhutan. In the numerator, *N* (healthcare staff) is the total number of healthcare staff participating in the provision of healthcare to the Bhutanese population (see below). The unit of the *N* (healthcare staff) will be equal to the number of healthcare staff per 1000 members of the Bhutanese population. To make the necessary conversion, the coefficient of 1000 is introduced in Eq. (1). The *EMIVI* was originally

defined and calculated to include only medical doctors as healthcare professionals critical to the effective healthcare system response (Kumpulainen, 2006). Medical doctors form the backbone of adequate medical care in the Kingdom of Bhutan (RGBRSC, 2016a). Nevertheless, the majority of the rural population will not receive disaster and primary healthcare from a doctor.

Recent disasters in the Himalayan region indicate that access to isolated rural settlements is difficult for days or weeks after the actual event. Under these conditions, the immediate healthcare respondents in the affected rural areas of Bhutan are likely to be all qualified healthcare professionals who are present or reside in the affected area(s). Official Statistics from the Annual Health Bulletin of the Ministry of Health of Bhutan indicate that data for the *EMIVI* calculations will have to include not just medical doctors (MD) and nurses (RN), but also health assistants (HA), assistant clinical officers (ACLO), basic health workers (BHW) and pharmacists (PH) (MOHB, 2011; MOHB, 2017). ACLO are medical professionals with first-aid training, some prescribing powers and they are also entrusted with basic medical care in isolated areas such as those without motor vehicle access (RGBRSC, 2016b). PH are routinely deployed in rural areas in developing countries such as the Kingdom of Bhutan and provide similar services to those offered by the ACLO.

HA and BHW are expected to be in a similar position as ACLO and Pharmacists on the ground in rural areas (MOHB, 2014), which have been affected by disasters. Traditional medicine plays an important role in healthcare provision in Bhutan as shown in a study by Lhamo and Nebel (2011). In the same study, up to 51 % of the respondents indicated that they use traditional healthcare practitioners in the treatment of various medical conditions (Lhamo & Nebel, 2011). This is likely to be the case in the disaster-prone and affected areas in the Kingdom of Bhutan, hence, traditional healthcare practitioners are likely to play an important role in healthcare provision in such areas during the response and recovery stages of the disaster management cycle. In the Kingdom of Bhutan, the traditional medical professionals are called Drungtshos (IF) and Sowa Penpas (SM) (MOHB, 2011; MOHB, 2017). Based on the above-mentioned facts, the numbers of IF and SM will be included in the *EMIVI* calculations. This means that the definition of the term *N* (healthcare staff) in the numerator in Eq. (1) includes the total numbers of RN, MD, ACLO, HA and BHW, PH, IF and SM in the Kingdom of Bhutan.

The vulnerability to epidemics relevant to the Kingdom of Bhutan was related to the WASH situation in Bhutan and the provision of improved drinking water sources and the population's access to improved sanitation facilities. A vulnerability index was derived to assess the WASH vulnerability of the Bhutanese population. The access to improved water resources and improved sanitation facilities was estimated by the percentage of the total population with access to these facilities. The actual values were obtained for the selected years in the 2000-2013 period and the source of raw data was the World Bank databases (WB, 2016a, 2016b). In the equation, percentages of the Bhutanese population with access to improved water resources are designated as X (%), while the respective sanitation values are designated as Y (%) in further texts. The WASH vulnerability index (WVI) was defined using the following approach.

Firstly, the aim was to avoid negative numbers for the WVI . Secondly, the index should increase with increasing WASH vulnerability, i.e. decreasing access to the improved drinking water resources and/or decreasing access to the improved sanitation facilities. Finally, the WVI should take into account both water and sanitation coverage of the population. Based on these points, WVI was defined as shown in Eq. (2).

$$WVI = \log \frac{1}{0.5*(X+Y)} \times 100 = \log \frac{200}{(X+Y)} \quad (2)$$

In Eq. (2), values of X and Y were averaged for a given calendar year, which explains the coefficient of 0.5 in the denominator on the right-hand side of Eq. (2). To achieve dimensionless WVI , X and Y were converted into fractions of the total population during calculations by incorporating the coefficient of 100 on the right-hand side of Eq. (2). WVI has the minimum theoretical value of 0, when 100 % of the Bhutanese population had access to improved water resources and improved sanitation facilities. As with X or Y or both decrease, the WVI values increase for the population in the Kingdom of Bhutan. By rearranging the coefficients in Eq. (2), the simplified version of WVI can be obtained as shown in the last term on the right-hand side of Eq. (2). The WVI definition is based in principle on the definition of biological activity as defined by Hansch and Fujita (1964). Unless stated otherwise, all calculations in this article were performed using OpenOffice Calc version 4.0 (The Apache Software Foundation, 2015) and/or the 2010 Microsoft Excel software.

Health status and vulnerability of the Bhutanese population was related to the economic and social conditions in the country (UNEP, 2008; WHO, 2010, p. 16). This can be expressed by calculating the economic and

social vulnerability indices. The authors decided to make the necessary calculations using André's (2012) approach for the 2000-2013 period. Data for gross domestic product per capita (GDPPC; USD), the fractions of the total population living in urban areas of the country (PLUA; the values reported as percentages were converted to fractions, dimensionless) and the population growth rate (PGR; the values reported as percentages were converted to fractions, dimensionless) were obtained from Index Mundi (Index Mundi, 2016b-d). The Human Development Index values were obtained from the United Nations database for the years 2010-2013 (HDIUN, year^{0.667}; UN, 2016). Data from 2000 until 2009 was only available for the calendar year of 2003 and therefore this value is assumed to be constant for the 2000-2009 period (BNHDR, undated). Because of the above-mentioned content, the economic (*EVI*) and social vulnerability (*SVI*) indices of the Bhutanese population were calculated using Eq. (3) and Eq. (4) as shown below (adapted from André, 2012).

$$EVI = \frac{PLUA \times \log(GDPPC)}{PGR \times HDIUN} \quad (3)$$

$$SVI = \frac{PLUA \times PGR}{HDIUN \times \log(GDPPC)} \quad (4)$$

Based on the above-mentioned information, *EVI* has a unit of USD×year^{1.5} and *SVI* is reported in year^{1.5}×USD⁻¹. For practical reasons, the *SVI* values are reported in 1000 ×year^{1.5}×USD⁻¹. These units are derived based on the definitions *EVI* and *SVI* indices. Correlation between the *WVI* values and the values of *EVI* and *SVI* using the Pearson correlation coefficient (Social Science Statistics, n.d. a). The statistical significance or a lack thereof for each correlation was assessed using the *p*-value for the Pearson correlation coefficient (Social Science Statistics, n.d. b). Results of the calculations and literature data collected are outlined in the next section.

Results and Discussion

The Royal Government of Bhutan has committed itself to the improvement of the healthcare sector in the country. This can, in turn, contribute to a decrease in the population's disaster vulnerability and an increase in disaster resilience. The improvement commitments and resulting

action led to the following improvement of health vulnerability indicators. The mean life expectancy of the Bhutanese population increased from 37 years of age in 1960 (WHO, 2014a) to 68-69 years of age in 2012-2013 (WHO, 2014b). Globally, increased life expectancy has not translated to a parallel increase in health life expectancy (HALE). On the contrary, HALE has increased more slowly in the last 20 years as more years gained with increased life expectancy were lost in increased years in coping with diseases and disabilities (Salomon, 2012). However, in the Bhutan case, their commendable and unique overarching policy of Gross National Happiness, responsible for major health and development strides, incorporates the calculation of happy life years as a product of life expectancy and the happiness score (Tobgay, Dophu, Torres, & Na-Bangchang 2011a)

Major government interventions were focused on tackling health problems such as non-communicable diseases (NCDs) (WHO, 2017b). These include interventions to curb the high intake of sodium chloride/edible salt in the everyday Bhutanese diet (WHO, 2017b). Further interventions dealt with lowering the rates of hypertension, affecting up to 25 % of the total population of the Kingdom (WHO, 2017b). The urgency of this intervention is supported by the results of a 2014 survey which indicated that one third of the population was classified as obese, the mean consumption of salt was 9 g per day per capita and 42.4 % of the population consumed excessive amounts of alcohol (Yangchen, Tobgay, Melgaard, 2017). A key tool in improving the NCD situation in Bhutan was the use and full implementation of the WHO Essential Intervention on non-communicable diseases (NCDs) in primary healthcare and in low-resource settings (WHO, 2010). Bhutan was the first country to ban the sale of tobacco, as it is one of the four trigger factors that accelerate the increase of NCDs globally (Tobgay, Dorji, Pelzom, & Gibbons 2011b).

NCDs can contribute to the increased vulnerability during disaster situations, especially in the context of climate change (IPCC, 2007). The integration of NCDs monitoring into the primary healthcare and development of early-detection strategies plays a key role in NCDs management in a country like Bhutan (WHO, 2010, pp. 4 & 7). This can also provide a mechanism for data collection and the assessment of one dimension of health and disaster vulnerability in the country. To decrease vulnerability and achieve as close to a universal access to healthcare as possible, development and implementation of the essential medicine list is critical (WHO, 2010, p. 7). Such a list has been compiled in the Kingdom of Bhutan (WHO, n.d). The urgency of the intervention in NCDs in Bhutan is further demonstrated by the

fact that up to 54.4 % of all deaths in Southeast Asia occurred due to NCDs in 2005 (WHO, 2010, calculated based on data in p. 15 Table 1), with another 21 % increase predicted for the 2006-2015 period (WHO, 2010, based on data in p. 15 Table 1).

Implementation of the essential strategies to deal with NCDs in “low-resource settings” can have the following benefits to the country’s healthcare system (WHO, 2010, p. 25-30; WB, 2011): Training of primary healthcare workers who are not medical doctors in effective management of complex medical conditions; mechanisms can be put in place to identify gaps in the capacity of the healthcare systems to deal with challenging and complex medical situations and impacts of sustainable development and; collection of data to continuously evaluate and improve implemented strategies and their impacts on the ground. This is of extreme importance as recent findings indicate that only 10 medical specialists were available in the entire territory of Bhutan to treat NCDs in 2011 (WB, 2011).

Like the disaster management cycle, the management of NCDs can only be successful if all risk factors, exposure routes and vulnerability triggers are addressed (Kivimäki et al., 2008). Some strategies have already shown effect as demonstrated by the decrease in the overall consumption of alcohol per capita per year in Bhutan, from 1.1 litres per annum between 2003 and 2005 to 0.7 litres per annum for the 2008-2010 period (WHO, 2014c). Policy tools that have been implemented to achieve this decrease include the introduction of excise taxes on alcohol, but some exemptions such as those on beer remain in place (WHO, 2014c). Gaps on enforcement also remain in place and this could be a hindrance to decreasing the risk factors related to NCDs in Bhutan.

According to the 2013 Statistical Report, the Bhutanese government’s data indicated that 95 % of the Kingdom’s population had access to a healthcare facility within 3 hours walking distance from their dwelling (SYBB, 2013). The majority of this access will likely be provided in government facilities, as government spending accounts for 88 % of the spending in the healthcare sector in Bhutan (Adhikari, 2016). Access to healthcare is provided through a combination of three types of healthcare facilities. Primary healthcare, especially in rural areas, is offered through the basic health units and the associated outposts/clinics (SYBB, 2013; Yangchen et al., 2017). These facilities are staffed by HA and BHW and provide health services to remote, mainly rural areas, of the Kingdom (SYBB, 2013; Yangchen et al., 2017). Above, the basic health units are regional referral hospitals and

the tertiary hospital with 350 beds that then provide the specialised healthcare at the national level (SYBB, 2013; Yangchen et al., 2017).

The primary healthcare facilities provide aid to the population in terms of various programmes that decrease the health vulnerability of the Bhutanese population. These include programmes focusing on the following public health priorities: Immunizations, reproductive health, respiratory infections, HIV/AIDS, TB, leprosy, the vector-borne diseases and mental health (SYBB, 2013). Such activities in primary healthcare have contributed to the reduction in many diseases. For example, the number of malaria cases dropped from 93 in 1993 to 1 in 2013 (Yangchen et al., 2017). However, challenges remain, namely; the infectious disease TB and HIVB/TB co-infections as well as in the equitable access to healthcare (Yangchen et al., 2017).

Overall, it can be seen that the government of Bhutan has taken some strides to decrease the vulnerability of its population. Prevention and mitigation programmes are in place and seem to be functioning well. However, the number of healthcare professionals need to be examined in detail. This is done by the calculations of the *EMIVI* values below. These calculations and the data analysis were premised on the official government statistics from the Kingdom of Bhutan (SYBB, 2013; 2014). Extracted data and the *EMIVI* calculations are summarised in Table 1.

Between 2008 and 2013, the expanded medical infrastructure vulnerability index ranged from 1.858 to 2.420 per 1000 inhabitants/citizens between 2008 and 2013. This means that Bhutan achieved the WHO target of 2.3 healthcare professionals per 1000 inhabitants, as outlined in the Millennium Development Goals (WHO, 2018). The main increase was recorded in the number of RN between 2011 and 2013. Bhutan has also integrated the traditional medicines systems into these health care facilities, thereby increasing the choices available to the population (Tobgay et al., 2011b). These positive developments will have an advantage in Bhutan's progress towards Sustainable Development Goal 3 (SDG 3) focusing on health. Further attention should be paid to the links between health and climate change. This is examined in the next few paragraphs.

Table 1

Structure of the Healthcare Workforce and the EMIVI Calculation Results (reproduced from SYBB, 2014, Tables 1.4 and 2.3).

Year	MD	RN	ACLO	HA	BHW	IF	SM	PH	N (healthc are staff)	N (popul- ation)	EMIVI
2008	171	567	43	425 ¹	36	54	14	1310	694990 ²	1.885	
2009	176	556	45	505 ¹	41	52	12	1387	695406 ³	1.995	
2010	187	556	44	366	169	43	63	11	1439	695822	2.068
2011	181	723	41	408	164	38	56	11	1622	708265	2.290
2012	194	736	39	416	162	35	63	11	1656	720674	2.290
2013	203	799	38	455	153	35	82	9	1774	733004	2.240

¹ Only combined figures were available.

² Extracted from www.populationpyramid.net (website accessed on 26th February 2018).

³ Estimated as the average of the 2008 and 2010 population.

The Global Environment Facility was created as a multi-lateral platform to enable the tackling of the challenges of sustainable development in the follow-up to the 1992 summit in Rio de Janeiro (GEF, 2017). The uniqueness of this platform is the participation of various United Nations agencies, up to 183 countries from around the world and major international banks (GEF, 2017). With the assistance of the Global Environment Facility, WHO and the UNDP, Bhutan became one of seven countries where the Climate Change Adaptation to protect human health project was launched as a test run in 2010 (WHO, 2017d). Specific focus in Bhutan was placed on the influence of climate change on the factors controlling the public health risks from vector-borne diseases (WHO, 2017d). These include the risks of malaria infections by *Plasmodium falciparum* and *Plasmodium vivax*; and dengue fever. These vectors include mosquitoes belonging to *Anopheles spp.* (Guerra et al., 2008) and *Aedes aegypti* and *Aedes albopictus* (Dhimal et al., 2014).

The Global Environment Facility project on climate change adaptation entered the implementation phase between 2010 and 2014 (GEF, 2010). The participatory approach to implementation formed one of the most fundamental aspects of the project as all relevant stakeholders were involved in the project's activities (GEF, 2010). Interlinking the early warning system about pending glacial lake outburst floods with the healthcare system and the necessary stakeholders in the Kingdom of Bhutan was implemented (GEF, 2010). Early warning systems should be expanded to take into account the factors controlling disaster risk (Tandlich et al., 2013a) in climate-related healthcare issues (GEF, 2010). Specific focus was on the epidemic control of the "disease peaks" (GEF, 2010).

There have been central focus areas that have been addressed in the context of Bhutan's participation in the Climate Change Adaptation to Protect

Human Health programme (WHO, 2017a): Increase the availability of reliable meteorological data about the impact of climate change on health outcomes; to improve financial resource and technical capacity of parts of the healthcare system in Bhutan to deal with the climate change influences on health outcomes in the Kingdom and; formation of an environmental health section in the National Ministry of Health of Bhutan. These aspects will fall under the umbrella term of environmental health. However, at the time of the preparation of this article, it was not possible to establish from the available resources, whether an environmental health section has been established in the Ministry of Health of the Kingdom of Bhutan.

It should however be noted that the National Environment Commission has been in place to oversee all environmental sector interventions, policy implementation and related programmes (Delek, 2010). It is a multi-stakeholder platform which oversees among others environmental impacts assessments (Delek, 2010). This platform could be used to carry out and coordinate initiatives in climate change and health, as it has already fulfilled this function in costing and proposing the pilot national programme on disaster management and emergency medicine in Bhutan (UNDP/GEF/RBOG, 2004). From a logistical point of view, this platform is also ideal as the Prime Minister of Bhutan is the chairperson of this entity (Delek, 2010). Since Bhutan is a constitutional monarchy, the Office the Prime Minister is the centre of political power (Ngqwala, et al., 2017) and so execution of the environmental health initiatives tabled at or approved by the National Environment Commission could facilitate the aims of the Climate Change Adaptation to Protect Human Health programme.

Further intervention to decrease the health vulnerability of the Bhutanese population have resulted in a number of improvements of the health indicators. The neonatal mortality decreased from 28.8 to 19.1 children per 1000 live births between 2004 and 2014 (WHO, 2014b). For the same period, mortality among the children under the age of 5 also dropped by 44.8 % (WHO, 2014b). Rates of vaccination against diphtheria, tetanus toxoid and pertussis has been steadily increasing from 89 % of the one-year old children in 2004 to 99 % of the same age category in 2014 (WHO, 2014b). This can be attributed to the implementation of health lifestyles and “comprehensive public health approaches” (WHO, 2010, p. 18). Data for the 2008-2012 period indicate that 59 % of women started early initiation of breast-feeding and that only 48.7 % of the female population that bore children exclusively breast fed their babies until 6 months of age (UNICEF,

2013). Between 2010 and 2014, the expanded medical infrastructure vulnerability index ranged from 1.98 to 2.55 per 1000 inhabitants/citizens.

Improvements in the water and sanitation provision also have added effects on the overall health status of the population (Hutton & Haller, 2004). Calculations of the *WVI* values was based on the World Bank datasets (WB, 2016a, b). The raw data and the *WVI* values for the total population of the Kingdom of Bhutan are shown in Table 2. Based on data for the 2000-2013 period, it is clear that the *X* value improved by 15.8 %, while the *Y* value increased by 18.6 %. This led to a steady decrease of the *WVI* from 0.241 in 2000 to 0.128 in 2013. The *EVI* and *SVI* indices were calculated and the respective data is depicted in Table 3. The *EVI* values increased from 60.55 USD×year^{1.5} in 2000 to 208.71 USD×year^{1.5} in 2013 (see Table 3 for details). There was a strong negative correlation between *WVI* and *EVI* (Pearson correlation coefficient = -0.9597) and this correlation was statistically significant at 5 % level of significance (*p*-value = 1.2×10⁻⁵).

The *SVI* values increased from 3.14 × 10⁻³ year^{1.5}×USD⁻¹ in 2000 to 3.35 × 10⁻³ year^{1.5}×USD⁻¹ in 2003. After this, there was a steady decrease in the values of the *SVI* and it reached a minimum value of 1.87 × 10⁻³ year^{1.5}×USD⁻¹ in 2013 (see Table 3 for details). There was a strong positive correlation between *WVI* and *SVI* (Pearson correlation coefficient = 0.8832) and this correlation was statistically significant at 5 % level of significance (*p*-value = 0.000706). The *WVI* was the dependent variable in both correlation, with *EVI* and *SVI* being the independent variables. These statistically-significant correlations point to the fact that the WASH vulnerability of the Bhutanese population strongly correlated with the variables of the economic development, social status of the Bhutanese population and urbanisation in the Kingdom. Such correlations can be used as a guide for policy development, adaptation and development.

Government is the largest provider of healthcare in the Kingdom of Bhutan, with its contributions accounting for up to 88 % of the total expenditure in the healthcare sector (Adhikari, 2016). The existing programmes to achieve universal health coverage must be further strengthened, e.g. health technology assessment, all in line with the principles of Gross National Happiness and through the related planning structures (Adhikari, 2016).

Table 2

The World Bank Source Data and WASH Vulnerability Calculation Results for the Total Population of the Kingdom of Bhutan

Year	X _{total} %	Y _{total} %	WV _{total} dimensionless
2000	83.9	31.0	0.241
2001	85.3	32.5	0.230
2003	87.9	35.7	0.209
2007	92.7	42.1	0.171
2008	93.8	43.6	0.163
2009	94.9	45.2	0.155
2010	96.0	46.8	0.146
2011	97.0	48.3	0.139
2012	98.0	49.4	0.133
2013	99.1	49.7	0.128

WHO experts have suggested that the exposure-response relationships should be studied in the context climate change and linking normally unlinked data (WHO, 2009). Health outcomes will be closely linked to the new approaches implemented in agriculture and drinking/overall water provision (WHO, 2009). These links include food security, nutritional status of the population, water stress and scarcity; and the need to interlink public health programme (diseases surveillance) and environmental information (WHO, 2009). Adaptive evaluation of the impacts of climate change must be performed on an ongoing basis (SERI, 2010). Use of climatic information and public health data will be of critical importance in predicting and managing the endemicity of diseases such as malaria and diarrhoea (WHO, 2009). Access to healthcare, variables controlling disaster risks related to climate change (Tandlich et al., 2013b) and “socio-economic status of the population” will play critical roles in this context (WHO, 2009, p.10).

The mitigation part of the disaster management cycle should be strengthened through increased training of the healthcare staff to recognise, diagnose and deal with health outcomes of climate change (WHO, 2017a). Awareness and empowerment at the community level of the Bhutanese society must also play a key role in the mitigation efforts throughout the Kingdom (WHO, 2017a). Some of these strategies have already been implemented and examples include the National Action Plan for the Prevention of Suicides in Bhutan for the 2015-2018 period (ROGB, 2015). Health authorities in Bhutan have put a specific focus on the improvement of the WASH situation in the Kingdom as the incidence of diarrhoea among children under 5 years of age decreased from 2368 cases per 10000 to 1755 cases per 10000 (ROGB, 2017, Table 2).

Table 3

The World Bank Source Data and the EVI/SVI Calculation Results for the Total Population of the Kingdom of Bhutan.

Year	HDIUN %	GDPPC USD	PLUA dimensionless	PGR Dimensionless	EVI USD × year ^{1.5}	SVI 1000× year ^{1.5} ×USD ⁻¹
2000	0.583	1100	0.2542	0.0219	60.55	3.14
2001	0.583	1200	0.2648	0.0217	64.45	3.20
2003	0.583	1400	0.2869	0.0214	72.35	3.35
2007	0.583	5200	0.3247	0.0208	99.50	3.12
2008	0.583	5200	0.3324	0.0130	16.,98	1.99
2009	0.583	4700	0.3401	0.0127	168.67	2.02
2010	0.583	5500	0.3479	0.0124	183.14	2.01
2011	0.582	6200	0.3559	0.0120	193.26	1.93
2012	0.589	6800	0.3637	0.0118	200.55	1.90
2013	0.595	7000	0.3714	0.0115	208.71	1.87

In further activities, authorities in the Kingdom of Bhutan need to improve rapid assessment tools, understanding water demand and management in the context of the health outcomes climate change and the related impacts relationship to food security and water provision (WHO, 2009). There is an urgent need to conduct “settings research”, i.e. focus on the development and implementation of local policies, as outlined in the concept of gross national happiness in the Kingdom of Bhutan (WHO, 2015). Other tasks should include conducting vulnerability assessment and risk mapping with respect to the climate-related diseases (WHO, 2017a). This activity should contribute to the collection of data on the existing incidence rates of these infections/diseases and changes in them (WHO, 2017a). This information will allow targeting of the limited financial, human and technical resources to priority areas; i.e. to improve disaster management planning in the Kingdom of Bhutan.

CONCLUSION AND RECOMMENDATIONS

Various programmes have been initiated in the Kingdom of Bhutan with focus on the health outcomes of climate change and the management of related risk factors. WASH vulnerability of the Bhutanese population strongly correlated with the variables of the economic development, urbanisation and social conditions in the country. Such correlations can be used as guide for policy development, adaptation and development for further vulnerability decrease in the Kingdom of Bhutan.

REFERENCES

- Adhikari, D. (2016). Healthcare and happiness in the Kingdom of Bhutan. *Singapore Medical Journal*, 57(3), 107-109.
- Ahmad, A.A. (2004). Water, water, water everywhere: Experience of Bangladesh in flood disaster risk management and need for cooperation in the Ganges, Brahmaputra and Meghna regions. *Journal of Rural Development*, 23(3), 279-295.
- Al Mandoos, A.A. (2017). *RA II contributions to GFCS*. Tokyo, Japan: World Meteorological Organisation.
- André, G. (2012). Natural hazard mapping across the world: A comparative study between a social approach and an economic approach to vulnerability. *Cybergeog: European Journal of Geography*. Retrieved from <http://cybergeog.revues.org/25297>
- Aziz, A., & Paul, A.R. (2015). Bangladesh Sundarbans: Present status of the environment and biota. *Diversity*, 7(3), 242-269.
- Bhutan National Human Development Report [BNHDR]. (2013). *The challenge of youth employment*. Bhutan: UNDP.
- Chalise, S. R., Shrestha, M. L., Budhathoki, K. P., & Shrestha, M. S. (2005) Glacio-hydrological aspects of climate change in the Himalayas: Mitigation of glacial lake outburst floods in Nepal. In T. Wagener, S. Franks, H. V. Gupta, E. Boegh, L. Bastidas, C. Nobre & C. D. O. Galvao (Eds.) *Regional hydrological impacts of climate change – Impact assessment and decision making*, Wallingford, UK: IAHS Press (pp. 309–316).
- Delek, T. (2010). *Japan's QSD implementation report: National Environmental Commission*. Retrieved from www.env.gov.jp/chemi/saicm/forum/100325/mat-03-1.pdf.
- Dhimal, M., Kumar A.K., Lamichhane, D.M., Gautam, I., Pratap, S.S., Lal, B.C., & Kuch, U. (2014). Knowledge, attitude and practice regarding

dengue fever among health communities in Central Nepal. *Plos One*, 9(7), 1-15.

Ehrlich, P.R., Kareiva, P.M., & Daily, G.C. (2012). Securing natural capital and expanding equity to rescale civilization. *Nature*, 486, 68–73.

Elalem, S., & Pal, I. (2015). Mapping the vulnerability hotspots over Hindu-Kush Himalaya region to flooding disasters. *Weather and Climate Extremes*, 8, 46-58.

Global Environment Facility [GEF] (2017). *About us*. Retrieved from www.thegef.org/aboutus.

Global Environment Facility [GEF] (2010). *Piloting climate change adaptation to protect human population. WHO/UNDP project report*. Retrieved from [www.who.int/entity/globalchange/news/GEF Project.pps](http://www.who.int/entity/globalchange/news/GEF_Project.pps).

Guerra, C.A., Gikandi, P.W., Tatem, A.J., Noor A.M., Smith, D.L., ... & Snow, R.W. (2008). The limits and intensity of *Plasmodium falciparum* transmission: Implications for malaria control and elimination worldwide. *Plos One*, 5(2), 0300-0311.

Hales, S., Kovats, S., Lloyd, S., & Campbell-Lendrum, D. (2014). *Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s*. Geneva, Switzerland: WHO Press. Retrieved from http://apps.who.int/iris/bitstream/10665/134014/1/9789241507691_eng.pdf?ua=1.

Hansch, C., & Fujita, T. (1964). Rho sigma pi analysis: A method for the correlation of biological activity and chemical structure. *Journal of the American Chemical Society*, 86(8), 1616-1626.

Hutton, G., & Haller, L. (2004). *Evaluation of the costs and benefits of water and sanitation improvements at the global level*. Geneva, Switzerland: WHO Press. Retrieved from http://www.who.int/water_sanitation_health/wsh0404.pdf.

- Index Mundi (2016a). *Life expectancy at birth for Bhutan (LEB)* Retrieved from <http://www.indexmundi.com/g/g.aspx?c=bt&v=30>
- Index Mundi (2016b). *GDP per capita in USD (GDPPC)* Retrieved from <http://www.indexmundi.com/g/g.aspx?c=bt&v=67>.
- Index Mundi (2016c). *Bhutan - Urban population*. Retrieved from <http://www.indexmundi.com/facts/bhutan/urban-population>
- Index Mundi (2016d). *Bhutan - Percentage population growth*. Retrieved from <http://www.indexmundi.com/g/g.aspx?c=bt&v=24>
- Inter-governmental Panel on Climate Change (IPCC, 2007). *Fourth assessment report*. Cambridge University Press. Retrieved from https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml
- Katel, O.N., Schmidt-Vogt, D., & Dendup, N. (2015). Transboundary water resources management in the context of global environmental change: The case of Bhutan Himalaya. In S. Shrestha, A.K. Anal, P.A. Salam & M. van der Valk (Eds.) *Managing water resources under climate uncertainty: Examples from Asia, Europe, Latin America, and Australia* Cham, Switzerland: Springer International (pp. 269-290).
- Kivimäki, M., Shipley, M.J., Ferrie, J.E., Singh-Manoux, A., Batty, G.D., Chandola, ... Smith, G.D. (2008). Best-practice interventions to reduce socioeconomic inequalities of coronary heart disease mortality in UK: A prospective occupational cohort study. *The Lancet*, 372 (9650), 1612-1613.
- Kumpulainen, S. (2006). *Vulnerability concepts in hazard and risk assessment*. In P. Schmidt-Thomé (Ed.) *Natural and technological hazards and risks affecting the spatial development of European regions*. Helsinki, Finland: Geological Survey of Finland, Special Paper 42 (pp. 65-74).
- Lhamo, N., & Nebel, S. (2011). Perceptions and attitudes of Bhutanese people on Sowa Rigpa, traditional Bhutanese medicine: A

preliminary study from Thimphu. *Journal of Ethnobiology and Ethnomedicine*, 7(3), pp 3-9.

Meenawat, H., & Sovacool, B.K. (2012). Bhutan: Modelling and adaptation in the eastern Himalayas. In A. Lamadrid & I. Kelman. (Eds.). *Climate change modelling for local adaptation in the Hindu Kush-Himalayan region*. Sussex, United Kingdom: Emerald Group Publishing Limited.

Ministry of Health of the Kingdom of Bhutan [MOHB] (2011). *Annual Health Bulletin 2011*. Retrieved from <http://www.health.gov.bt/wp-content/uploads/ftps/annual-health-bulletins/Annual%20Health%20Bulletin-2011/>

Ministry of Health of the Kingdom of Bhutan [MOHB] (2014). *Human resources for health country profile Bhutan*. Retrieved from http://www.searo.who.int/entity/human_resources/data/Bhutan_HRH_Country_Profile.pdf

Ministry of Health of the Kingdom of Bhutan [MOHB] (2017). *Annual health bulletin 2017*. Retrieved from <http://www.health.gov.bt/annual-health-bulletin/>

Ngqwala, N.P., Srinivas, C.S., Tandlich, R., Pyle, D.M., & Oosthuizen, R. (2017). Participatory multi-stakeholder platforms for effective disaster management in South Africa. *Journal of Disaster Research*, 12(6), 1192-1203.

Royal Government of Bhutan [ROGB] (2015). *Suicide prevention in Bhutan – A three-year action plan (July 2015-June 2018)*. Retrieved from www.health.gov.bt/wp-content/uploads/moh-files/2017/03/Suicide-Prevention-Action-Plan.pdf

Royal Government of Bhutan/Royal Civil Service Commission [RGBRCSC] (2016a). *General duties of the medical officer*. Retrieved from https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKewihndTbI8LKAhXBPxQKHee6AbMQFggiMAE&url=http%3A%2F%2Fwww.rcsc.gov.bt%2Fwp-content%2Fuploads%2F2014%2Fjob_description%2FMedical%2520Services%2FMedical%2520Services%2FGeneral%2520Duty%2520M

edical%2520Officer.doc&usg=AFQjCNGmd3rOYaU2IM76_ZnMfuPk5sTD_g&sig2=LYn8S95D7PEeYquP_pqrXA

Royal Government of Bhutan/Royal Civil Service Commission [RGBRCSC] (2016b). *Assistant Clinical Officer - General description*. Retrieved https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwihndTbI8LKAhXBPxQKHee6AbMQFggbMAA&url=http%3A%2F%2Fwww.rcsc.gov.bt%2Fwp-content%2Fuploads%2F2014%2Fjob_description%2FMedical%2520Services%2FPublic%2520Health%2520Services%2FAsst.%2520Clinical%2520Officer.doc&usg=AFQjCNHZGZzsNRAoHuUcbCI_KUyoO4MiPw&sig2=KRjXYRVD_0AsW50fXCZSNg

Salomon, J. A., Wang, H., Freeman, M. K., Vos, T., Flaxman, A. D., Lopez, A. D., & Murray, C. J. L. (2012). Healthy life expectancy for 187 countries, 1990–2010: A systematic analysis for the Global Burden Disease Study 2010. *The Lancet*, 380 (9859): 2144-2162.

Sivakumar, M.V.K., & Stefanski, R. (2011). Climate change in South Asia. In R. Lal, M.V.K. Sivakumar, M.A., Faiz, A.H.M. Mustafizur Rahman, K.R. Islam (Eds.) *Climate change and food security in South Asia*. Heidelberg: Germany: Springer Science+Business Media B.V. (pp. 13-30). Retrieved from http://www.springer.com/cda/content/document/cda_downloadocument/9789048195152-c2.pdf?SGWID=0-0-45-1117350-p174009161.

Social and Environmental Research Institute [SERI] (2010). *Promoting climate change awareness and adaptive planning in the Atlantic fisheries communities using participatory vulnerabilities analysis, mapping, and systems dynamic modelling (project summary)*. Retrieved from www.seri-us.org/content/fisheries-and-climate.

Social Science Statistics (n.d. a). *Pearson correlation coefficient calculator*. Retrieved from <http://www.socscistatistics.com/tests/pearson/Default2.aspx>

- Social Science Statistics (n.d. b). *P value from Pearson (R) calculator*. Retrieved from <http://www.socscistatistics.com/pvalues/pearsondistribution.aspx>.
- Southeast Asia Regional Office/World Health Organization [SEARO/WHO] (2006). *Health aspects of disaster preparedness and response panel session 1: Water-related hazards. Prehospital and Disaster Medicine*, 21(SUPPL.3), s79-s81.
- Statistical Yearbook of Bhutan [SYBB] (2013). Thimpu, Kingdom of Bhutan: National Statistics Bureau - the Royal Government of Bhutan.
- Statistical Yearbook of Bhutan [SYBB] (2014). Thimpu, Kingdom of Bhutan: National Statistics Bureau - the Royal Government of Bhutan.
- Tandlich, R., Hoossein, S., Whittington-Jones, K., & Moyo, F. (2013a). Emerging issues in environmental security and disaster management in South Africa. Proceedings of the 4th Virtual Scientific Conference on Scientific Reflection on New Trends in Management organised by the Czech and Slovak National Police Academies.
- Tandlich, R., Hoossein, S., Tagwira, K.A., Marais, M.M., Ludwig, T.A., Chidziva, R.P., ... & Wrench, W.M. (2013b). Emergency health management at a South African University. *International Journal of Information and Communication Engineering*, 7(6), 1853-1861.
- Tiraboschi, M. (2015). Preventing and managing natural and environmental disasters: Employment protection, welfare and industrial relations systems. *E-Journal of International and Comparative Labour Studies*, 4(3), 1-29.
- Tobgay, T., Dophu, U., Torres, C. E., & Na-Bangchang, K. (2011a). Health and gross national happiness: Review of current status in Bhutan. *Journal of Multidisciplinary Healthcare*, 4, 293-298.
- Tobgay, T., Dorji, T., Pelzom, D., & Gibbons, R. V. (2011b). Progress and delivery of health care in Bhutan, the Land of the Thunder Dragon

and Gross National Happiness. *Tropical Medicine and International Health*, 16 (6), 731-736.

Tusneem, M.E. (2011). Agriculture and food security. In A. Najam & M. Yusuf (Eds.) *South Asia 2060: Envisioning regional futures*. London, United Kingdom: Anthem Press (pp. 183-191).

Umaru, E.T., Ludin, A.N.M., Majid, M.R., Sabri, S., Chingle, M.P., Enegbuma, W., & Tajudeen, A.N.A. (2013). Risk factors responsible for the spread of meningococcal meningitis: A review. *International Journal of Education and Research*, 1(2), 1-30. Retrieved from <http://www.ijern.com/images/February-2013/19.pdf>.

UNICEF (2012). *Pneumonia and diarrhoea: Tackling the deadliest diseases for the world's poorest children*. New York, NY: Author.

UNICEF (2013). *Bhutan: Statistics*. Retrieved from www.unicef.org/infobycountry/bhutan_statistics.html.

United Nations [UN] (2016). *Bhutan - Human Development Indicators (Human Development Index/HDIUN)*. Retrieved from <http://hdr.undp.org/en/countries/profiles/BTN>

United Nations Development Programme/Global Environment Facility/Royal Government of Bhutan [UNDP/GEF/RGOB] (2004). *Bhutan Adaptation programme of action*. Retrieved from unfccc.int/resource/docs/napa/btn01.pdf. [Accessed on 18 July, 2017].

United Nations Environmental Programme [UNEP] (2008). *Inequity in access to clean water and sanitation*. Retrieved from <http://www.unep.org/dewa/vitalwater/article63.html>.

Wang, H., Dwyer-Lindgren, L., Lofgren, K.T., Rajaratnam, J.K., Marcus, J.R., Levin-Rector, A., ... Murray, C.J.L. (2012). Age-specific and sex-specific mortality in 187 countries, 1970-2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, 380 (9859), 2071-2094.

- Wilks, D., Farrington, M., & Rubinstein, D. (2003). *Infectious disease manual (2nd ed.)*. Oxford, United Kingdom: Blackwell Science.
- World Bank [WB] (2011). *South Asia human development, health nutrition and population: Non-communicable diseases in Bhutan*. Retrieved from [http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1296680097256/7707437-1296680114157/NCDs South Asia February 2011.pdf](http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1296680097256/7707437-1296680114157/NCDs_South_Asia_February_2011.pdf).
- World Bank [WB] (2016a). *Bhutan - Improved water source (% of population with access)*. Retrieved from <https://www.indexmundi.com/facts/bhutan/indicator/SH.H2O.SAFE.ZS>.
- World Bank [WB] (2016b). *Bhutan - Improved water source (% of population with access)*. Retrieved from <https://www.indexmundi.com/facts/indicators/SH.STA.ACSN/compare?country=bt>.
- World Health Organisation [WHO] (n.d.). *National list of essential medicines - Bhutan*. Retrieved from: <http://apps.who.int/medicinedocs/documents/s17826en/s17826en.pdf>.
- World Health Organisation [WHO] (2009). *Protecting the public health from climate change: Global research priorities*. Retrieved from: http://apps.who.int/iris/bitstream/10665/44133/1/9789241598187_eng.pdf
- World Health Organisation [WHO] (2010). *Package of essential non-communicable (PEN) disease interventions for primary healthcare in low-resource settings*. Geneva, Switzerland: Author.
- World Health Organisation [WHO] (2014a). *Bhutan-cooperation strategy at a glance*. Retrieved from http://www.who.int/countryfocus/cooperation_strategy/ccsbrief_btn_en.pdf?ua=1.

- World Health Organisation [WHO] (2014b). *Key country statistics*. Retrieved from <http://apps.who.int/gho/data/node.cco.latest?lang=en>.
- World Health Organisation [WHO] (2015). *National health promotion strategic plan 2015-2023*. Health/Royal Government of Bhutan. Retrieved from [www.aidsdatahub.org/sites/default/files/publication/Bhutan_National Health Promotion strategic Plan 2015-2023 2016.pdf](http://www.aidsdatahub.org/sites/default/files/publication/Bhutan_National_Health_Promotion_strategic_Plan_2015-2023_2016.pdf).
- World Health Organisation [WHO] (2017a). *Climate change adaptation to protect human health*. Retrieved from <http://www.who.int/globalchange/projects/adaptation/en/index2.html>
- World Health Organisation (WHO, 2017b). *Bhutan making its people healthier, happier by beating non-communicable diseases*. Retrieved from <http://www.who.int/features/2017/bhutan-noncommunicable-diseases/en/>.
- World Health Organisation (WHO, 2017c). *Kingdom of Bhutan – Health System Review: Health Systems in Transition*. Retrieved from apps.who.int/iris/bitstream/10665/255701/1/9789290225843-eng.pdf?ua=1.
- World Health Organisation (WHO, 2017d). *Climate change adaptation to protect human health*. Retrieved from <http://www.who.int/globalchange/projects/adaptation/en/>.
- World Health Organisation [WHO] (2018). *Health workforce: Achieving the health-related MDGs - It takes a workforce*. Retrieved from http://www.who.int/hrh/workforce_mdgs/en/
- Yangchen, S., Tobgay, T., & Melgaard, B. (2017). Bhutanese health and health care system: Past, present and future. *The Druk Journal*. Retrieved from <http://drukjournal.bt/bhutanese-health-and-the-health-care-system-past-present-and-future/>