Community Perception and Awareness of Climate Change and Pollution in a 'Hot Spot' Country- Myanmar (Burma): A Preliminary Research Investigation

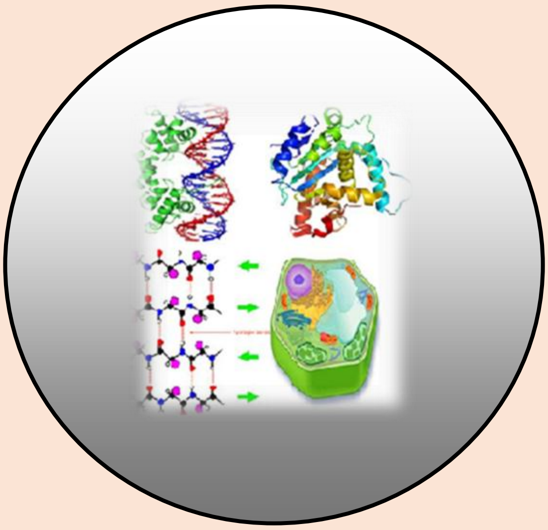
By

Golam Kibria

ISSN 2319-3077 Online/Electronic
ISSN 0970-4973 Print

Index Copernicus International Value
IC Value of Journal 82.43 Poland, Europe (2016)
Journal Impact Factor: 4.275
Global Impact factor of Journal: 0.876
Scientific Journals Impact Factor: 3.285
InfoBase Impact Factor: 3.66

J. Biol. Chem. Research
Volume 38 (1), 2021 Pages No. 126-144



Journal of Biological and Chemical Research

An International Peer Reviewed / Referred Journal of Life Sciences and Chemistry

Indexed, Abstracted and Cited in various International and National Scientific Databases

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 38, No. 1, 126-144, 2021
(An International Peer Reviewed / Refereed Journal of Life Sciences and Chemistry)
Ms 38/01/4952/2021

ISSN 2319-3077 (Online/Electronic)
ISSN 0970-4973 (Print)

Dr. Golam Kibria
http:// www.sasjournals.com
http:// www.jbcr.co.in
jbiolchemres@gmail.com

RESEARCH PAPER

Received: 14/02/2021 Revised: 17/02/2021 Accepted: 18/02/2021

Community Perception and Awareness of Climate Change and Pollution in a 'Hot Spot' Country- Myanmar (Burma): A Preliminary Research Investigation

Golam Kibria
School of Science, RMIT University, Melbourne, Australia

ABSTRACT

Myanmar ranks 2nd out of 187 countries in the Global Climate Risk Index in 2016. It is also threatened by water pollution due to direct discharge of agricultural, industrial, and mining effluents in waterways. A research investigation study (community perceptions and awareness) was carried out in Myanmar to seek views and opinions of urban and rural communities on climate change and water pollution. The research also included three case studies to assess possible risks and impacts of climate change (extreme events, warming), and pollutants (mercury, pesticides) on the social, economic, and environmental sectors. Based on the community's perception and awareness study, a new climate change and water pollution education program was planned, developed, and introduced at a local University and a government environmental department. The "community perceptions and awareness" research revealed that communities are much aware of climate change but are less familiar with water pollution problems. People in Myanmar are generally aware of climate change since they regularly experience the effects of extreme weather events (cyclones, floods, droughts). Gold mining (mercury) and rice production (pesticides) are the main causes of water pollution in Myanmar. This research study confirms that both climate change and pollution are a major problem and obstacle to achieving sustainability in Myanmar. To reduce risks of climate change, promotion of climate-smart agriculture, climate-smart villages, the use of renewable energy, afforestation/reforestation/mangrove restoration, low-carbon development and conservation of wetlands/mangroves would be vital. Similarly, to reduce risks posed by pollutants, on-going monitoring of mercury and pesticides in soil, water, food, the ecosystem and comparing with guidelines threshold values would be needed. Capacity building training and education related to climate change and pollution should be introduced in schools, colleges, and universities in Myanmar.

Keywords: Community Perception Climate Change, Pollution, Livelihoods, Biodiversity and Sustainability.

INTRODUCTION

The "community perceptions" are views, opinions and experiences of an individual community or a group of people associated with similar problems or issues (Atmadja and Sills, 2016).

Community perceptions can be used to formulate and design policies, strategies, and regulations (Maharjan and Joshi, 2013) to address the local sustainability problems/ issues such as climate change and pollution (Kibria et al*.,* 2017a). It is an economical and quick ways of ascertaining communities view (a snap-shot of the community's views) on complex issues like sustainability. For example, communities (e.g. farmers, teachers, students, government/private sector employees) may be facing different degrees of threats and risks posed by climate change and pollution in their everyday life (farming, ecosystems, drinking, or health-related) depending on their socio-economic and geographical locations and settings. Therefore, seeking community's opinion towards sustainability issues is an important step towards how the community perceives the associated risks in their local areas (Leiserowitz, 2007). Their views can then be incorporated into designing government policies, strategies, acts, and regulations to reduce or mitigate such problems. Lee et al*.,* 2015 carried out a first global assessment on climate change awareness and risk perception. The research found that 40 % of the adult population has never heard of climate change (of which 65 % in developing countries). Similarly, water pollution generated by domestic and industrial activities is the other emerging sustainability issues in developing countries. For example, of the 20 mismanaged plastic waste producers' countries in the world, 19 are from developing countries (Kibria, 2017). In fact, there is almost a lack of data and information about how communities perceive climate change and pollution issues in the most vulnerable developing countries, such as in Myanmar. Myanmar is regarded as one of the world's most climate-change-related disaster-prone countries. Myanmar ranks 2^{nd} out of 187 countries in the Global Climate Risk Index in 2016 (Kreft et al., 2016). It is also threatened by water pollution due to direct discharge of agricultural, industrial and mining effluents in waterways (Swe, 2019). The objectives of this research were to:

i. Seek views and opinions of urban and rural communities on climate change and water pollution in Myanmar,
ii. Carryout case studies on possible risks and impacts of climate change and pollutants on social, economic, and environmental sectors in Myanmar and
iii. Seek views and opinions of urban and rural communities on reducing threats and risks of climate change and water pollution in Myanmar.

MATERIALS AND METHODS

Four townships were chosen for the community perception survey on climate change and water pollution including two urban townships and two rural townships. These townships were: Kyauktan Township, Yangon (urban), Zan Bu Thiri Township, Nay Pyi Taw (urban), Natmauk Township, Magway Region (rural); and Winnzin Village, Meiktila (rural) (Figure 1). At each township, 20 community members (in total 80 communities from four townships) were randomly selected, which comprised both male and female, with a wide range of occupations (farmers, teachers, students, government employees and private job holders) and age groups (12 to 76 years) (Table 1). The communities participated voluntarily, who were willing to express their sustainability views in local Burmese language or in English. Each community members of the four townships were asked the following simple questions as part of this perception and awareness survey as listed below: i. Are you aware of climate change and water pollution issues at your locality ?, ii What is climate change and water pollution mean to you ? and iii. What is/ are your suggestions to reduce the risks posed by climate change and water pollution in Myanmar ? Communities awareness were analysed against each township/ sampling site using the bar graph and the standard deviation of the mean (SEM). Various responses (perception) on climate change and water pollution were categorised and analysed as percent of responses.

Three case studies were carried to assess risks of climate change (case study 1- climate change risks) and water pollution (case study 2- risks of mercury (Hg), case study-3 risk of pesticides) in Myanmar.

The climate risks assessment was based on the projected rise in temperatures, sea-level rise (SLR) and ocean acidification (OA) in Myanmar. The persistent, bio-accumulative, toxicity (PBT) and carcinogenicity of Hg, and pesticides were evaluated in assessing risks of mercury and pesticides pollutants.

Figure 1. Map of Myanmar showing the location of four sampling sites (red dots) used for community perception study on climate change and water pollution. Sites 1 and 2 are urban, sites 3 and 4 are rural.

Table 1. Information on four sampling sites (townships) and categorises of communities took part in the perception study.

Information on four sampling sites → **Categories of Participants** ↓	**Sampling site 1 (urban)** Kyauktan ward, Yangon GPS: 16^{O} 39’ 22.4”N, 96^{O} 17’ 20.8”E, male-15, female- 5 12-65 years	**Sampling site 2 (urban)** Zan Bu Thiri ward, Nay Pyi Taw GPS: 19^{O}44'28.66"N 96^{O} 06'29.31"E male- 2: female- 18, 19-68 years	**Sampling site 3 (rural)** Kwingyi, Aungtha, Thieechaung, Tanaunggon villages, Natmauk, Magway GPS: 20^{O}21’01”N 95^{O}24’05”E male- 11: female- 9, 19-61 years	**Sampling site 4 (rural)** Winnzin Village, Meiktila (rural) GPS: 20^{O}53’51.281”N 95^{O}1’32.239”E male- 12: female- 8, 25-76 years	**Total participants** (in four townships)
Farmers *(crops, vegetables, livestock, and fish farmers)*	3	-	7	8	18 (22.5 %)
Govt. employees *(clerks, officers, directors, nurses, village/ward administrators)*	4	18	3	1	26 (32.5 %)
Private job holders *(betel leaf growers, brokers, business owners, carpenters, company staffs, construction workers, motorbike carriers, house wives, shop owner/keepers, supervisors, taxi drivers, traders, vendor/sales person)*	9	1	6	8	24 (30 %)
Students *(schools and colleges)*	2	1	3	1	7 (8.75 %)
Teachers *(schools and colleges)*	2	-	1	2	5 (6.25 %)
Total	20	20	20	20	80 (100 %)

RESULTS AND DISCUSSION

Awareness

Community perception survey reveals that on an average 75 % of the communities are aware of climate change. Awareness trend further indicates that urban people are much familiar with climate change compared to rural people (Figure 2.1). People in Myanmar are generally aware of climate change since they regularly experience tropical cyclones, storm surges, floods, landslides, earthquakes, drought, and forest fires (OCHA, 2016) (see section 3.2.1). In contrast, only 52 % of the communities are aware of water pollution, of which, rural community are less familiar with water pollution (Figure 2.2). This may indicate that the water pollution problem has not been well promoted or prioritized in Myanmar though effluents discharged from industries (mining), agriculture (Swe, 2019) and pesticides run-off are major causes of water pollution in Myanmar (see section 3.3.3).

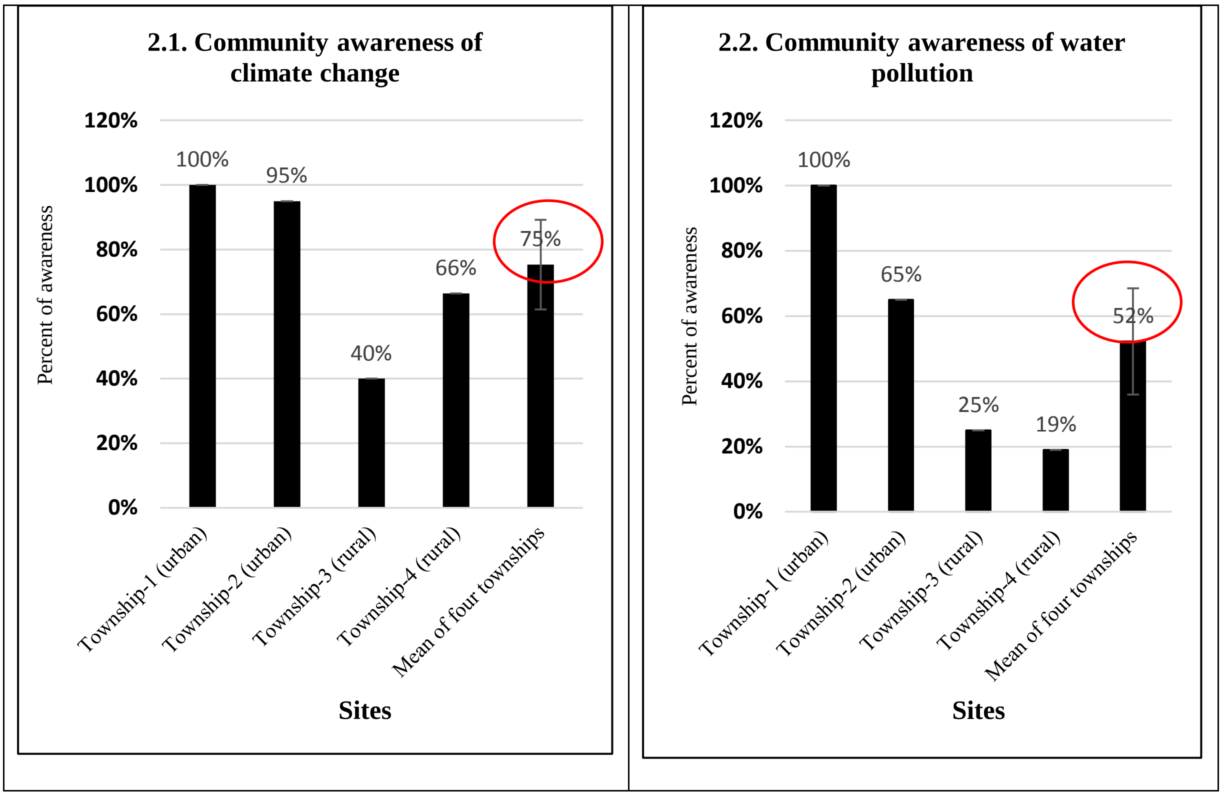


Figure 2. Community awareness of climate change (2.1) and water pollution (2.2) in Myanmar during 2018-2019. Four townships including two urban and two rural were chosen for this perception research.

Perception Responses

Climate Change

14 categories/types of responses (Figure 3) were provided by communities in relation to the question of what climate change is meant to them. They are: rise in temperatures, increases in the frequency and intensity of droughts, floods, cyclones/typhoons/hurricanes, earthquakes, avalanches, landslides. heavy rainfalls, hot days, increases in greenhouse gases (GHGs) in the atmosphere, changes in weather/climate patterns, increase in rainless/less rainfall days, global warming, a drop/decrease in paddy/rice yield, a trend in frequent drying of community ponds/streams/tube wells, a shift in season etc. (Figure 3) of the 14 categories/types of responses, temperature rise, droughts, floods, GHGs, and cyclones/typhoons/hurricanes accounted for the predominant (57 %) responses (Figure 3).

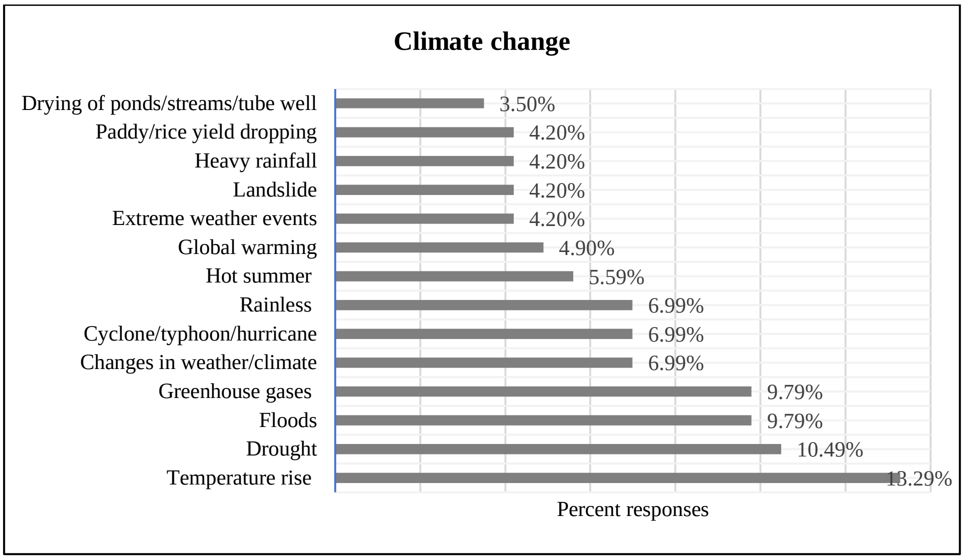


Figure 3. Community responses of climate change.

The major communities' opinion/views related to climate change (temperature rise, drought, floods and cyclones) (Figure 3, see case study 1-climate change risks on agriculture, fisheries, and ecosystems in Myanmar and measures to reduce risks) is a true reflection of their own life-experience in Myanmar as discussed below. In Myanmar, the average daily temperature has increased by 0.25^{O} C per decade, and the daily maximum temperatures by 0.4^{O} C between 1981 and 2010. It is projected that warming will increase by 0.7-1.1^{O} C by 2011-2040 (Horton et al*.,* 2017). The prevalence of drought events has increased in Myanmar and the severe droughts are reported from 1990 to 2002 and again in 2010. The 2010 drought caused water shortages in rural areas impacting agricultural production including rice, tomato, sugarcane and peas (*https://climateknowledgeportal.worldbank.org/country/myanmar-burma/vulnerability*). The flood of 2015 affected major areas in Myanmar when approximately 1.7 million people were temporarily displaced (OCHA, 2016). In May 2008, the Cyclone Nargis (world's deadliest cyclones) affected 2.4 million and killed more than 140,000 people (OCHA, 2016). The waves of cyclone Nargis was estimated to be 3 to 4 m high (Tasnin et al*.,* 2015) and destroyed 75 % of buildings in the Irrawaddy Delta (*http://news.bbc.co.uk/2/hi/asia-pacific/7382298.stm)*.

Case study 1. Climate change risks on agriculture, fisheries, and ecosystems in Myanmar and measures to reduce risks

Myanmar is most vulnerable to the effects of climate change and ranked #2 (1995-2014) in the Global Climate Risk Index (CRI) (Kreft et al*.,* 2016). It is projected that climate change will increase in temperature and the frequency and intensity of droughts, cyclones, floods, and storm surges (MCCA, 2020). Therefore, agriculture, ecosystems and biodiversity will be impacted.

- ***Agriculture:*** Myanmar is an agricultural country employing 65 % of the labour force (*https://en.wikipedia.org/wiki/Agriculture_in_Myanmar).* Myanmar's agriculture is predominantly a rain-fed. The projected increase in droughts will have a major impact on cereal crops in the dry zones. According to Peng et al., 2004, a 1°C increase in growing-season minimum temperature would cause 10 % less rice grain yield (an important agriculture commodity in Myanmar). Moreover, temperature >35°C would reduce photosynthesis (by chloroplast damage), and cause spikelet sterility (reduced pollen production) in rice (Wassaman, 2009).

Though elevated CO_2 (CO_2 fertilization) would stimulate plant growth (Hennessy 2011) and benefits C_3 plants (wheat, rice and soybean) (Rogers et al*.,* 1994), however, CO_2 fertilization would also decrease in protein and minerals content in rice and wheat (Taub et al*.,* 2008, DaMatta et al*.,* 2010, Loladze, 2014). Low-lying coastal rice cultivation areas in Myanmar will decline and be impacted due to increased salinity (salt) and inundation due to SLR (Kibria, 2018a).

- ***Livestock***: With higher temperatures and overall decreased water supplies, beef-cattle, and sheep farming are likely to experience increased incidences of stress-related deaths, the reduction in animal weight, reproduction rates and milk yields in Myanmar (Kibria et al*.,* 2013).

- ***Fisheries and Aquaculture****:* Climate change may cause migration of wild fish species out of Myanmar to cooler areas to escape the warmer water/heat stress. The ocean acidification (OA) would adversely affect marine organisms that use calcium carbonate for their skeletons and would cause a decrease in the abundance of commercially exploited seafood organisms. SLR would cause salinization of freshwater fisheries and aquaculture facilities and in turn, would damage/destroy coastal ecosystems including mangroves and salt marshes (habitat for wild fish stocks). The extreme weather events would destroy seagrass, seaweed beds and mangroves (important nursery areas for fishes) (Kibria et al*.,* 2017b).

- ***Ecosystems and Biodiversity:*** The rise in temperature may cause biodiversity of Myanmar to stay in the same environment or move out in a suitable environment (polewards or higher elevation) or to go deep (fish) to increased depths in the oceans to escape warming or to die out/get extinct (Kibria et al., 2016). Climate change can cause significant impact on Myanmar's rainforests biodiversity. For example, the long dry season may cause late leaf production, late flowering, late plant reproduction in forests, causing significant impacts on pollinators (bees) and frugivores (birds) (Morellato et al*.,* 2016). The rising temperature would lower dissolved oxygen (DO) concentrations in lakes. Water with low oxygen level could cause suffocation of fish resulting in death, Kibria, 2014).

- ***Reducing Risks:*** To reduce risks of climate change, implementation climate-smart agriculture, climate-smart villages (Kibria, 2018a), use of renewable energy, afforestation/reforestation/mangrove restoration, conservation of wetlands/mangrove habitats (which act as major carbon sinks) and capacity building of communities on climate change risks would be vital (see also the section 4 for reducing risks of climate in Myanmar via capacity development education and training program).

Water pollution

Nine categories/types of responses (Figure 4) were provided by communities in relation to the question of what water pollution is meant to them. They were: effluents from industries (mining), and farming, pesticides used in rice-growing, surface runoff of mixed chemicals, saltwater intrusion due to SLR, oil, washing and bathing in waterways and silt. Of the nine categories/types of responses, effluents from industries (mining), farming (agriculture), pesticides accounted for the predominant (64 %) responses (Figure 4).

In Myanmar, major water pollution sources are known to be mining (acid mine drainage, heavy metals leaching), and pesticides used to grow paddies and wastewater discharged from industries (Myint, 2020). In fact, mining is one of the main causes of water pollution, contaminating community water sources with mercury, cyanide, arsenic (Bell et al., 2017, MCRB, 2018).

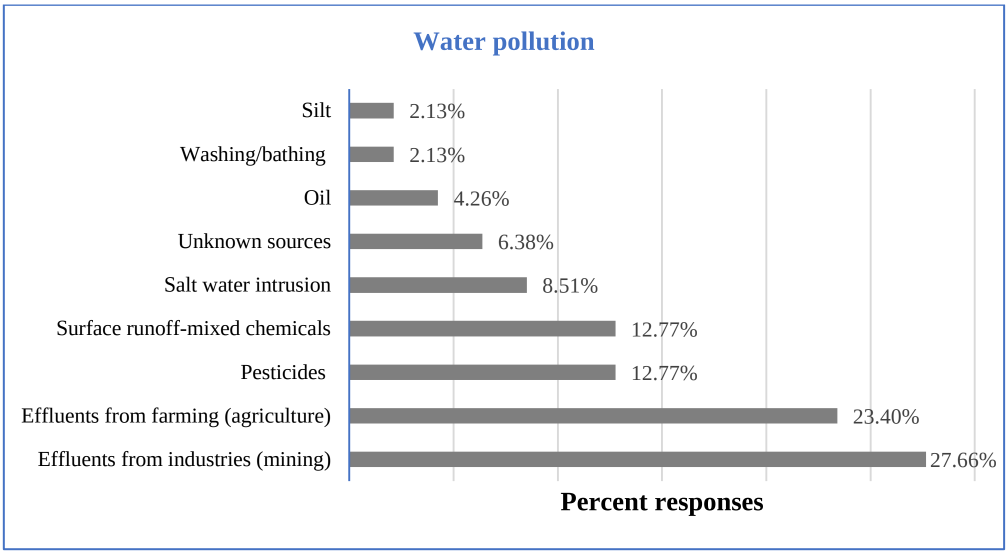


Figure 4. Community responses of water pollution.

The major communities' opinion/views related to water pollution (mercury and pesticides pollution) (Figure 4) are a true reflection of their own life-experience in Myanmar as discussed below. Communities along the Ayeyawady (Irrawaddy) River, Chindwin River and Tanintharyi River depend on these rivers for drinking, household use and irrigation. However, these rivers are contaminated with mercury as a result of gold mining (Bell et al., 2017) (see case study 2 for mercury risks on water and human health in Myanmar and measures to reduce risks). In addition, mining is also responsible for contamination of groundwater, community wells, creeks, pond, drinking water, paddy lands and cattle poisoning (MCRB, 2018). A Global research study found elevated Hg levels in child-bearing women in 25 countries including Myanmar. These women were exposed to Hg via consumption of local fish and rice contaminated with Hg due to pollutants load from artisanal and small-scale gold mining (ASGM) activities. Hg concentration in women's hair was 2.264 ppm (parts per million) compared to health safety threshold values of 0.58 ppm) (Bell et al., 2017). Hg level of more than 0.58 ppm can cause foetal neurological damage. An estimated 173,375 people work in Myanmar's artisanal and small-scale gold mining (ASGM) sector.
(*https://www.unenvironment.org/news-and-stories/story/mercury-monitoring-myanmar-gets-boost*).

Pesticides are extensively used in agriculture in Myanmar to grow crops like rice, jute, wheat, corn, peanuts, beans, cotton, sugarcane, rubber, vegetables to increase food production. There is a strong belief among farmers in Myanmar that pesticides must be used for rice growing since these chemicals would increase rice yields (*https://ricehopper.wordpress.com/tag/myanmar-farmers-insecticide-use/#:~:text*). Nevertheless, the use of pesticides has increased in Myanmar over the years (Myint, 2020). Based on a 2012 survey, several pesticides are used to grow rice in Myanmar including acephate, carbofuran, cypermethrin, deltamethrin, diazinon, dimethoate, endosulfan, imidacloprid, malathion, phenthoate. The above insecticides are banned/stopped using in other countries (*https://ricehopper.wordpress.com/tag/myanmar-farmers-insecticide-use/#:~:text=*) and very harmful to fish, bees, birds and mammals (case study 3 -pesticides risks on water, biota and human health in Myanmar and measures to reduce risks). Moreover, farming communities usually throw away used pesticide containers or bottles into waterways (canals, rivers) without knowing its harmful effects. It caused both contaminations of water as well as killed fish (EEI, 2018).

Case study 2. Mercury (Hg) risks on water and human health in Myanmar and measures to reduce risks

Ayeyawady (Irrawaddy) River in Myanmar
(Photo: Golam Kibria, October 2018).

Hg discharged from mining is one of the main causes of water pollution in Myanmar. Hg is widely used to recover gold in soil/sediment in ASGM. In Myanmar, the suspected Hg impacted areas include communities along the Ayeyawady River (Irrawaddy River) (Kibria, 2018b). Ayeyawady River is the largest River in Myanmar, the water of which is used for drinking, household use and irrigation. However, the Ayeyawady River water has been contaminated with Hg released from mining.
The river sediments of Ayeyawady were found with the highest Hg concentrations of 81 µg/g Hg (Osawa and Hatsukawa, 2015). A global research study also found elevated Hg levels in child-bearing women living in the ASGM areas in Myanmar, who were exposed to Hg via consumption of local fish and rice contaminated with Hg (Bell et al., 2017). There are several risks of Hg. For instance, MeHg (methyl-mercury) can accumulate in fish tissues (ANZECC, 2000, Kibria et al., 2010). In addition, MeHg in the soil can be absorbed in rice roots and can then be translocated to leaf, stalk and ultimately to rice grains (Meng et al., 2011). MeHg is a potent neurotoxin (Ullrich et al., 2001) and is possibly carcinogenic to humans (IARC 2B) (IARC, 2019). Mercury is extremely toxic to fish (Kibria et al., 2010).

Reducing risks: To reduce the risks of Hg, on-going national monitoring of Hg in soil, water, food, ecosystems and comparing with the guideline threshold values would be required. The direct discharge of effluents from mining into waterways should also be stopped.

Case study 3. Pesticides risks on water, biota and human health in Myanmar and measures to reduce risks

Rice field in Myanmar
(Photo: Golam Kibria, October 2018).

Rice production accounts for 43 % of total agricultural production in Myanmar. Pesticides used in rice are one of the main causes of water pollution in Myanmar. Based on a 2012 survey, the following 10 pesticides (as shown in dot points). These pesticides are very harmful to biota) fish, *Daphnia*, birds, bees, or mammals) as follows:

- acephate- moderately toxic to birds (LD_{50}: 350 mg/kg), bees (LD_{50}: 1.2 µg/bee),
- carbofuran- extremely toxic to mammals (LD_{50}: 8 mg/kg), *Daphnia* (LC_{50}: 0.038 mg/L),
- cypermethrin- highly bioaccumulative (log K_{ow} 6.6), extremely toxic to fish (LC_{50}: 0.69 mg/L), bees (LD_{50}: 0.035 µg/bee),
- Deltamethrin- highly bioaccumulative (log K_{ow}: 4.6), extremely toxic to fish (LC_{50} 0.91 mg/L), bees (LD_{50}: 0.079 µg/bee),
- diazinon- probably carcinogenic (IARC 2A), extremely toxic to birds (LD_{50}: 2.7 mg/kg), *Daphnia* (LC_{50}: 0.00096 mg/L),
- dimethoate- highly toxic to birds (LD_{50}: 10.5-42 mg/kg), bees (LD_{50}: 0.1-0.2 µg/bee),

- endosulfan-highly bioaccumulative (log K_{ow}: 4.79), extremely toxic to fish (LC_{50}: 0.002 mg/L),
- imidacloprid- moderately toxic to mammals (LD_{50}: 450 mg/kg), toxic to bees,
- malathion-probably carcinogenic (IARC group 2A), extremely toxic to fish (LC_{50}: 0.1 mg/L),
- phenthoate- bio-accumulative (log K_{ow}: 3.69) moderately toxic to fish (LC_{50}: 2.5 mg/L) (Tomlin, 2000, Kibria et al., 2010).

Humans can be exposed to pesticides residues via contaminated food (rice, wheat, maize), animals (fish, livestock), milk and milk products, eggs and contaminated water (Kibria, 2010).

Reducing risk: To reduce the risks of pesticides, on-going national monitoring of pesticides in soil, water, food, ecosystems and comparing with the guideline threshold values would be required. It is also essential to prevent using banned pesticides. Communities should also be educated about the risks posed by banned pesticides.

*(Note: **IARC**= International Agency for Research on Cancer, **LC_{50}** = lethal concentration, that kills, 50 % of the test animals, **LD_{50}** = lethal dose which causes the death of 50 % of test animal, **log K_{ow}** = Octanol/ Water Partition Coefficient).*

Reducing threats and risks of climate change and water pollution in Myanmar

Case studies 1, 2, 3 in section 3 reviewed possible risks posed by climate change and pollutants (mercury and pesticides) on various social, economic, and environmental sectors and measures to reduce such risks in Myanmar. In addition, and as part of the perception and awareness research, communities also provided four responses in relation to the question of what should be done to reduce the risks of climate change and water pollution? Their responses were: i. introduce climate change and water pollution education and training at local schools, colleges and universities and Government environmental departments, ii. train up communities on climate-smart agriculture and climate-smart villages, iii. train up communities on climate change and pollution management; iv. supply simple environmental awareness and education materials. Responses i and ii accounted for predominant (66 %) answers (Table 3). Accordingly, and as part of the risk reduction on climate change and pollution, a new climate change and water pollution management capacity development education training program was planned, developed and introduced at the Environmental Conservation Department (ECD) and The University of Forestry and Environmental Science (UFES) in Myanmar during 2018-2019 (Table 4). The capacity development program introduced at ECD and UFES were planned in a way that is aligned to global sustainable development goals (SDGs) and based on Myanmar's social, economic and environmental perspectives (Table 4).

Table 3. Suggestions of communities to reduce risks of climate change and water pollution management in Myanmar.

Categories of responses	Number of responses				
	Sampling site 1 (urban)	Sampling site 2 (urban)	Sampling site 3 (rural)	Sampling site 4 (rural)	Total and percent of responses
Introduce climate change and water pollution management education at schools, colleges and universities and Government institutes in Myanmar	20	10	6	17	53 (38.4 %)

Train up communities on climate-smart agriculture and climate-smart village in Myanmar	18	10	6	4	38 (27.5 %)
Train up communities on climate change, and pollution management in Myanmar	-	6	8	10	24 (17.4 %)
Supply simple environmental awareness and education materials on climate change and pollution management in Myanmar	-	11	6	6	23 (16.7 %)

Table 4. Main components of capacity development education and training program introduced on climate change and water pollution in Myanmar (as part of the research) and aligned with global sustainable development goals (SDGs).

*[**As** = arsenic, **ATSDR** = Agency for Toxic Substances and Disease Registry, USA, **BTEX** = benzene, toluene, ethylbenzene and xylene: **GHGs** = greenhouse gases, **Hg** = mercury, **PAHs** = Polycyclic aromatic hydrocarbons, **PBT** = persistent, bioaccumulative and toxic, **SDGs** = sustainable development goals (SDGs), **TRIMPs** = trimethyl pentane containing passive samplers].*

Main theme	Education and training components introduced and taught at UFES and ECD	Alignment to global sustainable development goals (SDGs) and their relevant targets	Remarks (rationale for inclusion in climate change and water pollution education and training)
Climate change	i. Climate change *impacts on forests and wetlands*, case studies, forests and wetlands in climate mitigation	SDG13 (*life on land*): conserve and restore forests and wetlands.	Myanmar has a significant forest (48 % of the country)[1] and five Ramsar wetlands[2]), both forests and wetlands act as carbon sinks[3]**.**
	ii. Climate change *impacts on agriculture, water, fisheries*	SDG1 (*no poverty*), SDG2 (*no hunger*): build the resilience of the poor and the vulnerable sectors (agriculture, water, and fisheries).	Myanmar is an agricultural country employing 65 percent of the labour force[4],
	iii. Climate-smart agriculture (CSA), climate-smart villages (CSV).	SDG 2 (*no hunger*): i. promote CSA (sustainable food production while reducing emissions of GHGs); ii. promote CSVs (rainwater harvesting, no-tillage farming, agroforestry, nutrient management, drought, flood, salt-tolerant seeds, solar energy and knowledge enhancement).	CSA would enhance productivity, resilience to climate change and reduce GHG emissions[5],

	iv. *Ocean acidification* (OA) impacts on seafood security and livelihoods.	SDG14 (*life below water*): protect marine and coastal biodiversity	Myanmar is rich with marine biodiversity (578 marine fish, 287 corals, 71 rays, 57 sharks, 42 crabs, 41 bivalves, 38 seaweeds, 12 seagrasses)[23], on which community depend for food, water, wood, fuel and livelihoods.
	v. Climate change *Impacts on women* in developing countries.	SDG1 (*no poverty*), SDG2 (*no hunger*): Build the resilience of the poor women affected in Myanmar.	Women in Myanmar is Principally associated with agriculture[6].
	vi. *Low carbon development* (LCD) in different sectors.	SDG7 (*promote affordable and clean energy*), SDG13 (*climate action*).	Promote LCD in Myanmar to reduce GHG emissions and vulnerabilities of climate change impacts on various sectors and achieving the targets of global SDGs[7].
	vii. *Food wastes and climate change*: food waste impacts on climate change, water resources and strategies to reduce food wastes.	SDG12 (*responsible consumption and production*) (substantially reduce waste generation including food waste and methane production).	The city of Yangon, Myanmar generates 2,300-2,550 waste each day[26], of which 77 % is food waste/organic waste[27], food waste sent to landfill emits methane gas (CH_4), the global warming potential of CH_4 is 21 times higher than carbon dioxide[22].
	viii. *Hydropower dams* in the context of climate change mitigation.	SDG13 (*climate action*): promote hydropower as a source of energy supply where feasible.	Myanmar has 27 hydropower plants[8], hydropower is renewable energy with low GHG emissions.
Water pollution	i. *Metalloid/heavy metals* (HMs) pollution: chemistry, toxicity and ecotoxicity of HMs, case studies, monitoring of heavy metals using artificial mussel's technology, guidelines, management,	SDG12 (*responsible consumption and production*): responsible management of metalloids/ heavy metals to reduce their release to air, water and soil.	In Myanmar, gold is mined in three states, and two divisions. Hg from gold mines contaminated rivers[9], several HMs are carcinogenic, can bioaccumulate in crops, vegetables, marine fish and thus humans via the food chain[9].

	ii. *Pesticides pollution*: chemistry, toxicity and ecotoxicity of pesticides, pesticide residues in food, water, human breast milk, case studies, monitoring of pesticides in waterways Using passive sampling technology (TRIMPS), guidelines and management.	SDG12 (*responsible consumption and production)*: responsible management pesticides to reduce their release to air, water and soil.	Several pesticides are used in rice growing[10] in Myanmar, which can contaminate food, water and ecosystems[11,12]
	iii. *Plastic waste and plastic pollution*: chemistry, toxicity and ecotoxicity of plastics, plastic additives, mismanaged plastic waste, case studies, impacts on biodiversity and seafood, adsorption of contaminants, management.	SDG12 (*responsible consumption and production)* (substantially reduce waste generation including micro and macroplastics) to reduce their release to air, water, and soil.	Microplastics (MP) as waste is recorded up to 28,000 MP /km in Myanmar's coastline[17], MPs can be ingested by aquatic biota and wildlife; pollutants adsorbed in MPs can contaminate seafood[18,19].
	iv. *Nutrient pollution*: nexus among nutrients-hypoxia-dead zones, management of nutrients.	SDG12 (*responsible consumption and production):* responsible management of nutrients to reduce their release to air, water and soil.	Agriculture and sewage are the dominant sources of nutrient inputs in rivers in Myanmar[13], nutrients can cause hypoxia, (dissolved oxygen< 2 mg/L) and mass mortality of fishes and benthos[14].
	v. *Oil pollution:* chemistry, toxicity and ecotoxicity of oil compounds (BTEX, PAHs); impacts of oil spill on biodiversity and ecosystems (birds, fish, plankton, seagrasses, corals, mangroves), management of oil spill and oil pollution.	SDG12 (*responsible consumption and production*): responsible management of oil compounds to reduce their release to air, water and soil.	About 73 ships come to the seaport in Myanmar every year and there is a likelihood of accidents/oil spills[24], oil compounds are sensitive to fish, corals, seagrasses and mangroves[15].

	vii. *Dioxins pollution*: chemistry, toxicity and ecotoxicity of dioxins, effects on biota and human's health and management.	SDG12 (*responsible consumption and production)*: responsible management of dioxins, furans to reduce their release to air, water and soil.	Open burning is a popular method of waste management in Myanmar which releases super toxic "dioxins"[16]
	viii. *Electronic wastes pollution* (e-waste): toxic chemicals in e-waste; risk of e-waste, and reducing e-waste generation	SDG12 (*responsible consumption and production*) (substantially reduce waste generation including e-waste and e-waste related chemicals) to reduce their release to air, water and soil.	In 2016, 55 kt (1 kg/capita) e-waste was generated in Myanmar[25], e-waste is a source of hazardous chemicals[20], which can contaminate soil, groundwater and nearby agriculture land[21].

[1]*https://en.wikipedia.org/wiki/Deforestation_in_Myanmar*
[2]*https://www.mmtimes.com/news/our-wetlands-are-worth-saving.html*
[3]*https://www.researchgate.net/publication/316315104_Climate_Change_Impacts_on_Wetlands_of_Bangladesh_its_Biodiversity_and_Ecology_and_Actions_and_Programs_to_Reduce_Risks*
[4]*https://en.wikipedia.org/wiki/Agriculture_in_Myanmar#:~:text=Agriculture*
[5]*https://www.worldbank.org/en/topic/climate-smart-agriculture*
[6]*http://www.fao.org/myanmar/news/detail-events/en/c/385218/*
[7]*https://content.iospress.com/articles/journal-of-climate-change/jcc180006*
[8]*https://link.springer.com/article/10.1007/s13201-019-0984-y*
[9]*https://www.researchgate.net/profile/Golam-Kibria/publication/328732643_Presentation_Heavy_metals-Its_Risk_on_the_Environment_Water_Food_and_Public_Health/links/*
[10]*https://ricehopper.wordpress.com/tag/myanmar-farmers-insecticide-use/*
[11]*https://www.researchgate.net/publication/332781637_Presentation_Pesticide_Pollution-_Risk_and_Impact*
[12]*https://www.researchgate.net/publication/266618490_Pesticides_and_Its_Impact_on_the_Environment_Biodiversity_and_Human_Health-_A_Short_Review*
[13]*https://link.springer.com/article/10.1007/s10113-017-1176-7*
[14]*https://www.researchgate.net/publication/331275314_Nutrient_Pollution_Causing_Algal_Blooms_Hypoxia_Dead_Zones_Across_the_Globe_Impacting_Ecosystems_Biodiversity_Public_Health_Livelihoods*
[15]*https://www.researchgate.net/publication/333091943_Oil_Spill_and_Oil_Pollution-_A_Threat_to_Wildlife_Fisheries_Seafood_Security_and_Ecosystems*
[16]*https://www.who.int/news-room/fact-sheets/detail/dioxins-and-their-effects-on-human-health#:~:text=Dioxins%20are%20highly%20toxic%20and,expected%20to%20affect%20human%20health.*
[17]*https://www.thantmyanmar.com/en/news/plastic-pollution-in-myanmar-119-tons-of-plastic-waste-enter-the-ayeyarwady-river-every-day#:*
[18]*https://www.researchgate.net/publication/319391174_Plastic_Waste_Plastic_Pollution-_A_Threat_to_All_Nations*
[19]*https://www.researchgate.net/publication/327230697_Presentation_Plastic_Pollution-_Sources_Global_Production_Global_Hotspots_Impacts_on_Biodiversity_Seafood_Adsorption_of_Organic_Inorganic_Chemicals_and_Mitigation*

[20]https://www.who.int/ceh/capacity/eWaste_and_childrens_health_DRAFT.pdf?ua=1
[21]https://www.researchgate.net/publication/261216635_Climate_Change_and_Chemicals_Environmental_and_Biological_Aspects
[22]https://www.researchgate.net/publication/316547640_Food_Waste_Impacts_on_Climate_Change_Water_Resources
[23]https://www.mmtimes.com/news/myanmar-ups-efforts-save-marine-wildlife.html
[24]https://www.mmtimes.com/news/government-finalise-oil-spill-contingency-plan-2018.html
[25]https://globalewaste.org/countrystatistics/myanmar-2015/
[26]https://www.channelnewsasia.com/news/asia/myanmar-food-scraps-fertiliser-environment-waste-yangon-12804430
[27]https://archive.iges.or.jp/files/research/scp/PDF/20160613/17_Quick_study_Web.pdf

CONCLUSION

The "community perceptions" research reveals that communities in Myanmar are much aware of climate change. However, communities are less familiar with water pollution problems (Figures, 2.1, 2.2). The case study carried out shows that climate change will likely pose significant threats in Myanmar on agriculture, livestock, fisheries, and aquaculture; ecosystems and biodiversity (case study 1). Gold mining and rice production are the main causes/sources of water pollution in Myanmar. Hg discharged from gold mines contaminated drinking, household use, irrigation, and river water in Myanmar (case study 2). Several pesticides are used in growing rice (case study 3). Runoff of these pesticides residue from rice fields can contaminate both surface and groundwater (case study 3).

To reduce risks of climate change, and water pollution in Myanmar, the following measures should be implemented

- Promote climate-smart agriculture, climate-smart villages, use of renewable energy, low-carbon economic development, afforestation/reforestation/mangrove restoration, conservation of wetlands/mangrove habitats and capacity building of communities on climate change risks.
- On-going monitoring of mercury, and pesticides in soil, water, food, ecosystems and comparing with the guideline threshold values would be required.
- Direct discharge of effluents from mining and rice farming into waterways should also be stopped.
- Introduce climate change and water pollution management training and education at local schools, colleges and universities and Government environmental departments
- New research should be prioritized to assess the interactive effects of climate change and pollutants on agriculture, biota, forests, fisheries, seafood, water, and wetlands on which the majority of rural communities depend for food, fuel, materials, protein, and livelihoods

ACKNOWLEDGEMENTS

The author acknowledges the support and cooperation received from the Environmental Conservation Department (ECD) and The University of Forestry and Environmental Science (UFES) in Myanmar. In particular, the assistance provided by the Director-General of ECD (U Hla Maung Thien) and the Rector of the UEFS (Prof. Dr. Myint Oo) were much helpful. Dr. Nyein Chan and Dr. Eithandar Bol facilitated Golam Kibria in smooth running of climate change and environmental pollution courses (Training of Trainers of 13 departments) at the UFES. Special appreciation to U Sein Htoon Linn (Deputy-Director General (DDG), Dr. San Oo (DDG), U Min Maw (DD-PCD) and Dr. Win Win Mar for their much-needed moral, logistic, and other support to run capacity development training on climate change and pollution at ECD.

The following Officers of ECD (as part of their capacity development training) collected some raw field data on perception and awareness [(Aye Sandar (Ms), Kyaw Win Hlaing (Mr), May Myat Mon (Ms), Moe Myint Myint Shein (Ms), Myo Zaw Win (Mr), Thaw Thaw Han (Ms), Thinn Thiri Aung (Ms), Thu Zar Myint (Ms), Thura Zarni Soe (Mr), Tin Mar Thien (Ms), and Win Myint (Mr)]. The study was possible through an assignment (Environmental Impact Assessment Specialist) to the author by the Australian Federal Government (Aus-Aid) to Myanmar. Lastly, the capacity development education and training program introduced on climate change and water pollution in Myanmar (Table 4) can be applied to other developing countries in Asia and Africa (with some modifications).

REFERENCES

ANZECC (2000). Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 2, Aquatic ecosystems – rationale and background information. National Water Quality Management Strategy (Chapter 8) *http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_ water_quality/volume_2.*

Atmadja, S.S. and Sills, E.O. (2016). What Is a "Community Perception" of REDD+? A systematic review of how perceptions of REDD + have been elicited and reported in the Literature. PLoS ONE. 11(11), e0155636. pmid: 27802284.

Bell, L., Evers, D., Johnson, J., et al., (2017). Mercury in women of child-bearing age in 25 countries. IPEN and BRI.69 p; *http://ipen.org/mercury-and-women, https://ipen.org/sites/default/files/documents/updateNov14_mercury-women-report-v1_6.pdf*

DaMatta, F. M., Grandis, A., Arenque, B.C. and Buckeridge, M.S. (2010). Impacts of climate changes on crop physiology and food quality. *Food Research International*. 43, 1814-1823.

EEI (The Economy and Environment Institute – Lower Mekong Subregion) (2018). The impact of pesticide use on human health: A case study from Myanmar. EEI-LMS POLICY BRIEF: NO. 2017-PB3.
http://www.eepseapartners.org/wp-content/uploads/2018/01/2018-01-PB3-MayLinAung_final.pdf

Hennessy, K. (2011). Climate change impacts, chapter 4, p. 45-57. In: Climate Change: Science and solutions for Australia. Helen Cleugh, Mark Stafford Smith, Michael Battaglia, and Paul Graham (Eds.). CSIRO, Australia. CSIRO Publishing, Collingwood, Victoria, Australia.

Horton, R., De Mel, M., Peters, D., et al. (2017). Assessing climate risk in Myanmar: Technical report. New York, NY, USA: Centre for Climate Systems Research at Columbia University, WWF-US and WWF-Myanmar *https://c402277.ssl.cf1.rackcdn.com/publications/1006/files/original/Final_Technical_Report_Assessing_Climate_Risk_in_Myanmar.pdf?1494428197*

IARC (International Agency for Research on Cancer) (2019). IARC monographs on the identification of carcinogenic hazards to humans. https://monographs.iarc.fr/agents-classified-by-the-iarc/

Kibria, G., Haroon, A.K.Y., Nugegoda, D. and Rose, G. (2010a). Climate change and chemicals: Environmental Biological aspects. New India Publishing Agency. New Delhi. 470 p. ISBN: 9789380235301, https://www.researchgate.net/publication/261216635_Climate_Change_and_Chemicals_Environmental_and_Biological_Aspects

Kibria, G., Haroon, A.K.Y. and Nugegoda, D. (2013). Climate change and agricultural food production: Impacts, vulnerabilities and remedies. New India Publishing Agency, New Delhi, India. 300 p. ISBN: *9789381450512, DOI:0.13140/2.1.3245.4081*

Kibria, G. (2014). Global fish Kills: Causes and consequences. *DOI: 10.13140/RG.2.1.1422.8965* *https://www.researchgate.net/publication/261216309_Global_fish_Kills_Causes_and_Consequences*

Kibria, G., Haroon, A.K.Y. and Nugegoda, D. (2016). Climate change and water security: Impacts, future projections, adaptation, and mitigations. 312 p., ISBN: 978-93-85516-26-9. DOI: 10.13140/RG.2.1.1848.1528/1

Kibria, G. (2017). Plastic waste, plastic pollution- A threat to all nations! DOI: 10.13140/RG.2.2.11169.51048

Kibria, G., Haroon, A.K.Y. and Nugegoda, D. (2017a). An innovative model for engagement of rural citizens/ community of Bangladesh with climate Change. *Journal of Climate Change*. 3 (2), 73–80.*DOI 10.3233/JCC-170015*

Kibria, G., Haroon, A.K.Y. and Nugegoda, D. (2017b). Climate change impacts on tropical and temperate fisheries, aquaculture, and seafood security and implications - A eview. Livestock Research for Rural Development. 29 (1), 1-16. *https://www.lrrd.org/lrrd29/1/kibr29012.htm*

Kibria, G. (2018a). Climate change risk in agriculture and fisheries. Managing climate change risk. Some thought! *DOI: 10.13140/RG.2.2.36630.45126.* *file:///C:/Users/User1/Downloads/GolamKibria_PPP_ClimateChangeImpctsAgrFisheries_29july18%20(20).pdf*

Kibria, G. (2018b). Heavy metals- Its risk on the environment, water, food and public health. *DOI:10.13140/RG.2.2.19560.93445* *https://www.researchgate.net/publication/328732643_Presentation_Heavy_metals Its_Risk_on_the_Environment_Water_Food_and_Public_Health*

Kreft, S., Eckstein D., Dorsch L. and Livia Fischer, L. (2016). Global climate risk index 2016. Who suffers most from extreme weather events? Weather-related loss events in 2014 and 1995 to 2014 *https://germanwatch.org/sites/germanwatch.org/files/publication/13503.pdf*

Lee, T.M., Markowitz, E.M., Howe, P.D., Ko, C.Y. and Leiserowitz, A.A. (2015.) Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*. 5, 1014-1020. *DOI 10.1038/ nclimate2728*

Leiserowitz, A. (2007). Public perception, opinion and understanding of climate change—current patterns, trends and limitations. United Nations Development Programme, New York

Loladze, I. (2014). Hidden shift of the ionome of plants exposed to elevated CO_2 depletes minerals at the base of human nutrition. eLife. 3:e02245. DOI: 10.7554/eLife.02245

Maharjan, K.L. and Joshi, N.P. (2013). Community perceptions of climate change and its impacts. Chapter 10. Pages 139-164. In: Climate Change, Agriculture and Rural Livelihoods in Developing Countries, Advances in Asian Human-Environmental Research, *DOI 10.1007/978-4-431-54343-5_10, © Springer Japan 2013.*

MCCA (Myanmar Climate Change Alliance) (2000). Impact of Climate Change and the Case of Myanmar*https://myanmarccalliance.org/en/climate-change-basics/impact-of-climate-change-and-the-case-of-myanmar/#link9*

Meng, B., Feng, X., Qiu, G., et al. (2011). The process of methyl-mercury accumulation in rice (*Oryza sativa* L.) *Environmental Science and Technology*. 45(7), 2711-2717. *doi: 10.1021/es103384v. Epub 2011 Mar 2.*

MCRB (Myanmar Centre for Responsible Business) (2018). Sector wide impact assessment of limestone, gold and tin mining in Myanmar. 245p. *https://themimu.info/sites/themimu.info/files/documents/Report_Mining_Sector-Wide_Impact_Assessment_MCRB_Mar2018.pdf*

Morellato, P., Alberton, B., Alvarado, S.T., et al. (2016). Linking plant phenology to conservation biology. *Biological Conservation*. 195, 60–72.

Myint, S. (2020). Water pollution control challenges in Myanmar. *https://www.dwir.gov.mm/images/world-water day/3.Water%20Pollution%20Control%20Challenges%20in%20Myanmar.pdf (accessed on 15 December 2020)*

OCHA (The United Nations Office for the Coordination of Humanitarian Affairs) (2016). Myanmar: Natural disaster risks and past events. OCHA, Relief and Resettlement Department, UN, USGS. *https://reliefweb.int/sites/reliefweb.int/files/resources/Natural%20disaster%20risks%20and%20past%20events_as%20of%2031May2016.pdf*

Osawa, T. and Hatsukawa, Y. (2015). Artisanal and small-scale gold mining in Myanmar: *International Journal of Human Culture Studies*. Issue. 25, 221-230. *DOI: 10.9748/hcs.2015.221*

Rogers, H. G., Runion, G.B., Krupa, S.V. (1994). Plant responses to atmospheric CO_2 enrichment with emphasis on roots and the rhizosphere. *Environmental Pollution*. 83, 155-189.

Swe, L.L.W. (2019). Overview of water pollution in Myanmar. Briefing Note. Regional fellowship program. Parliamentary Institute of Cambodia. *https://www.pic.org.kh/images/2019Research/20191014_Overview%20of%20Water%20Pollution%20in%20Myanmar.pdf*

Tasnim, K. M., Shibayama, T., Esteban M., et al. (2015). Field observation and numerical simulation of past and future storm surges in the Bay of Bengal: case study of cyclone Nargis, Natural Hazards. 75(2), 1619-1647.

Taub, D. R., Miller, B. and Allen, H. (2008). Effects of elevated CO_2 on the protein concentration of food crops: a meta- analysis. *Global Change Biology*. 14, 565-575.

Tomlin, C.D.S. (2000). A world compendium – *The Pesticide Manual.* 12th edition. Editor: CDS Tomlin. British Crop Production Council. 49 Downing Street, Farnham, Surrey GU9 7 PH, I UK. 1250 p

Ullrich, S.M., Tanton T.W. and Abdrashitova S.A. (2001). Mercury in the Aquatic Environment: A Review of Factors Affecting Methylation. *Critical Reviews in Environmental Science and Technology*. 31 (3), 241–293. doi:10.1080/20016491089226. S2CID 96462553.

Wassmann, R, S., Jagadish, V.K., Heuer, S et al. (2009). Climate change affecting rice production: the physiological and agronomic basis for possible adaptation strategies. *Advances in Agronomy*. 101, 59-122.

Websites

https://en.wikipedia.org/wiki/Deforestation_in_Myanmar
https://www.mmtimes.com/news/our-wetlands-are-worth-saving.html
https://www.researchgate.net/publication/316315104_Climate_Change_Impacts_on_Wetlands_of_Bangladesh_its_Biodiversity_and_Ecology_and_Actions_and_Programs_to_Reduce_Riskshttps://en.wikipedia.org/wiki/Agriculture_in_Myanmar#:~:text=Agriculture
https://www.worldbank.org/en/topic/climate-smart-agriculture
http://www.fao.org/myanmar/news/detail-events/en/c/385218/
https://content.iospress.com/articles/journal-of-climate-change/jcc180006
https://link.springer.com/article/10.1007/s13201-019-0984-y
https://www.researchgate.net/profile/Golam-Kibria/publication/328732643_Presentation_Heavy_metals-Its_Risk_on_the_Environment_Water_Food_and_Public_Health/links/
https://ricehopper.wordpress.com/tag/myanmar-farmers-insecticide-use/
https://www.researchgate.net/publication/332781637_Presentation_Pesticide_Pollution-Risk_and_Impact
https://www.researchgate.net/publication/266618490_Pesticides_and_Its_Impact_on_the_Environment_Biodiversity_and_Human_Health-_A_Short_Review

https://link.springer.com/article/10.1007/s10113-017-1176-7
https://www.researchgate.net/publication/331275314_Nutrient_Pollution_Causing_Algal_Blooms_Hypoxia_Dead_Zones_Across_the_Globe_Impacting_Ecosystems_Biodiversity_Public_Health_Livelihoods
https://www.researchgate.net/publication/333091943_Oil_Spill_and_Oil_Pollution-A_Threat_to_Wildlife_Fisheries_Seafood_Security_and_Ecosystems
https://www.who.int/news-room/fact-sheets/detail/dioxins-and-their-effects-on-human-health#:~:text=Dioxins%20are%20highly%20toxic%20and,expected%20to%20affect%20human%20health.
https://www.thantmyanmar.com/en/news/plastic-pollution-in-myanmar-119-tons-of-plastic-waste-enter-the-ayeyarwady-river-every-day#:
https://www.researchgate.net/publication/319391174_Plastic_Waste_Plastic_Pollution-A_Threat_to_All_Nations
https://www.researchgate.net/publication/327230697_Presentation_Plastic_Pollution-Sources_Global_Production_Global_Hotspots_Impacts_on_Biodiversity_Seafood_Adsorption_of_Organic_Inorganic_Chemicals_and_Mitigation
https://www.who.int/ceh/capacity/eWaste_and_childrens_health_DRAFT.pdf?ua=1
https://www.researchgate.net/publication/261216635_Climate_Change_and_Chemicals_Environmental_and_Biological_Aspects
https://www.researchgate.net/publication/316547640_Food_Waste_Impacts_on_Climate_Change_Water_Resources
https://www.mmtimes.com/news/myanmar-ups-efforts-save-marine-wildlife.html
https://www.mmtimes.com/news/government-finalise-oil-spill-contingency-plan-2018.html
https://globalewaste.org/countrystatistics/myanmar-2015/
https://www.channelnewsasia.com/news/asia/myanmar-food-scraps-fertiliser-environment-waste-yangon-12804430
https://archive.iges.or.jp/files/research/scp/PDF/20160613/17_Quick_study_Web.pdf

Corresponding author: Dr. Golam Kibria, School of Science, RMIT University, Melbourne, Australia
Email: kibriagolam0@gmail.com