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Climate Adaptation Strategies for Bamboo Drip Irrigation System in Meghalaya

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Abstract: *The rise in temperatures and the resultant climate change is widely considered as the biggest challenge to humanity in 21st century. What makes the challenge of climate change unique and worrying is its omnipresence: climate change, in future, will affect all countries, continents and communities. The impacts of climate change will be varying in magnitude as highly vulnerable regions will be more affected than other regions. One of the communities which is highly vulnerable to climate change is the tribal community of Meghalaya in North East India. This research paper attempts to analyse the threats posed by climate change to the traditional bamboo drip irrigation system in Meghalaya. This paper also attempts to list down, explain and analyse the most suitable adaptation strategies to shield this traditional rainwater harvesting system from the impacts of climate change and then provide a preference order among the adaptation strategies according to the feasibility of each adaptation strategy. Also, the paper discusses a seven-stakeholder model where seven relevant stakeholders are recognised and policy recommendations for each in making tribal communities climate-resilient in North East India have been discussed. This paper is an attempt to not just contribute to academic literature on climate change but to provide feasible, scalable and replicable solutions with an aim to contribute towards the fight against climate change.*

Keywords: Bamboo Drip Irrigation, Climate Adaptation, Climate Change

Introduction

Ecologically unsustainable economic growth, since the beginning of Industrial revolution, has led to increase in greenhouse gases in the atmosphere. These greenhouse gases have the ability to trap heat radiations reflected by the surface of Earth because of which the heat gets trapped in the atmosphere of the planet and is unable to go back into space. This has resulted in steady rise in temperature of the planet. Rise in temperature of the planet has led to alteration of ecological balance and it is leading to modification of climate across the world. Climate change is an *existential threat* to humanity and thus, requires effective adaptation and mitigation strategies and collaborative actions of governments. It must be noted that to deal with the issue of climate change effectively, there is a need to prioritise climate action in those areas which are highly vulnerable to the possible impacts of climate change. The state of Meghalaya is one such area and requires immediate adaptation actions so as to minimise the future impacts of climate change in the state. Meghalaya is home to various tribes which have their own unique set of procedures, lifestyle and systems like the bamboo drip irrigation system, which is being practiced by the Khasi and Jaintia tribes of Meghalaya for the last 200 years. Due to climate change, this traditional rainwater harvesting system is also under threat and requires immediate actions which can evolve the system into a climate-resilient one.

Objectives of the research paper include analysis of vulnerability of Meghalaya to the impacts of climate change; analysis of specific threats to Bamboo drip irrigation system in Meghalaya; presenting possible adaptation strategies which can be adopted to shield Bamboo drip irrigation system from the impacts of climate change; analysis of feasibility of each adaptation strategy on basis of indicators like number of threats addressed, affordability, accessibility, availability and fit to local tribal culture; and figuring out various stakeholders (and their respective roles) who can possibly play a role in making tribal areas of Meghalaya climate resilient.

Research Question*: How challenges posed by climate change to bamboo drip irrigation in Meghalaya can be addressed?*

The rationale for conducting this research can be understood from three arguments. First, the adaptation strategies which this research paper highlights can be utilised to shield the traditional bamboo drip irrigation system from the impacts of climate change. Second, this research paper addresses the issue of *ecological marginalisation* of tribal communities by highlighting the threat to their rainwater harvesting system. Third, the adaptation strategies recommended by this paper are scalable in nature in a way that they can be replicated in other regions of the world where a similar system for rainwater harvesting is in place.

Concepts Involved

Global warming: According to the IPCC Special Report 'Global warming of 1.5° C', global warming is defined as *an increase in combined surface air and sea surface temperatures averaged over the globe and over a 30-year period*(Global Warming of 1.5° C, 2021). Global warming is a result of the rise in greenhouse gases like carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) in the Earth's atmosphere. Greenhouse gases have the ability trap the heat waves radiated from the surface of the Earth, which otherwise were supposed to escape the Earth's atmosphere into the space. As a result of presence of greenhouse gases in the atmosphere, the temperature of the planet is rising continuously. According to the recent IPCC report, in 2021, the temperature has risen by 1.2° C from the average temperatures of pre-Industrial levels.

Climate change: According to IPCC, *climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period typically decades or longer* (Global warming of 1.5° C, 2021). Climate change can have possible impacts on economy, security, culture, society and polity of all communities and countries in the world. It is to be noted that unlike other developmental issues like poverty or hunger, climate change has a deadline for action/window of opportunity to mitigate and adapt to the crisis so as to avoid unprecedented loss to human and biodiversity. It is because of this reason that climate change is considered as the biggest challenge of 21st century.

Methodology

Qualitative methodologies like field works and questionnaires have been used to collect data on various indicators of possible adaptation strategies like its affordability, accessibility, availability and to what extent it is fit to the culture of the tribal community.

Quantitative approach is used for analysis of the feasibility component of each adaptation strategy. Each adaptation strategy has been scored out of 100 on basis of quantitative analysis. On basis of qualitative and quantitative analysis, a preference order, in decreasing order of the feasibility score, of possible adaptation strategies has been designed.

Therefore, the research utilises mixed approach, where qualitative methodologies provides the initial data and quantitative methodologies analyse the data. The result of the quantitative data analysis will tell us which adaptation strategies are most suitable and feasible to implement. Sources for Data Collection include surveys, questionnaires, climate analytics and IPCC reports.

Vulnerability of Meghalaya to Climate Change

There are multiple reasons due to which Meghalaya is considered as highly vulnerable to climate change. First reason is the location of the state. Although the rise in temperature is faced by the whole world, the magnitude of rise differs from region to region and Indian Subcontinent is one of the regions where temperature rise due to climate change average is higher than average global temperature rise. North East India, being a part of the subcontinent is also experiencing faster rise in temperature. Second reason is the natural resources. Climate change, as a phenomenon, is impacting natural resources. Therefore, more the abundance of natural resources in a region more is the possibility climate-induced impact. Meghalaya has abundance of natural resources which includes water resources like rivers, lakes, mountain springs, forests and biodiversity. Third reason is widespread agriculture which is rain fed in nature.

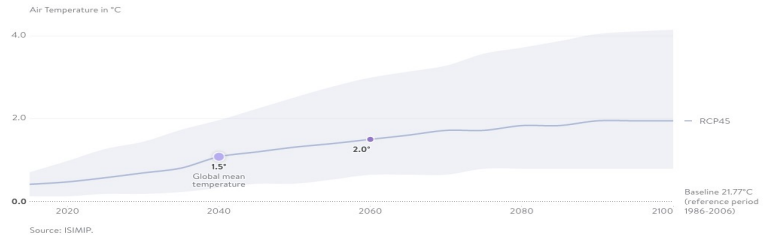

Figure 1 (a): Rise in air temperature of Meghalaya by 2100 due to climate change (source: https://climateanalytics.org/tools/)

Figure 1(b): Variation in rice yield due to climate change in Meghalaya by 2100 (source: https://climateanalytics.org/tools/)

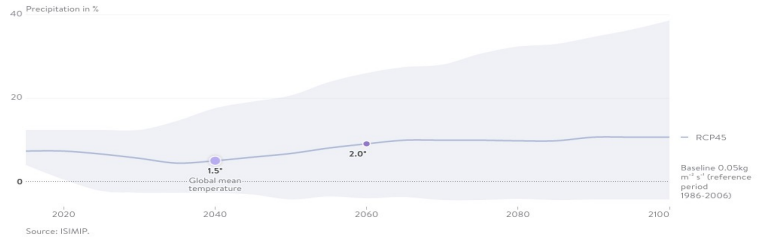

Figure 1(c): Variation in precipitation in Meghalaya by 2100 due to climate change (source: https://climateanalytics.org/tools/)

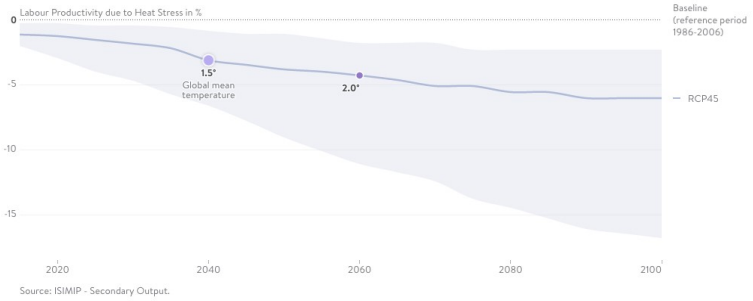

Figure 1(d): Decrease in labour productivity due to heat stress in Meghalaya by 2100 (source: https://climateanalytics.org/tools/)

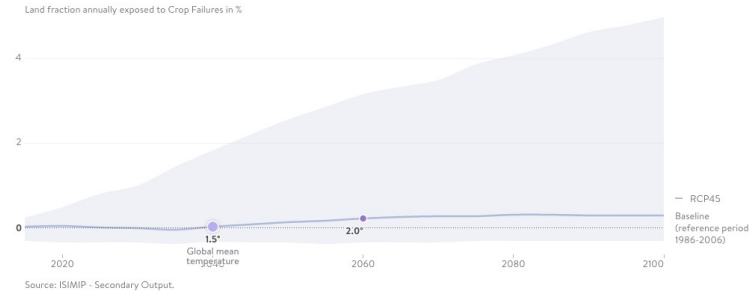

Figure 1(e): Rise in land fraction exposed to crop failure in Meghalaya by 2100 due to climate change (source: https://climateanalytics.org/tools/)

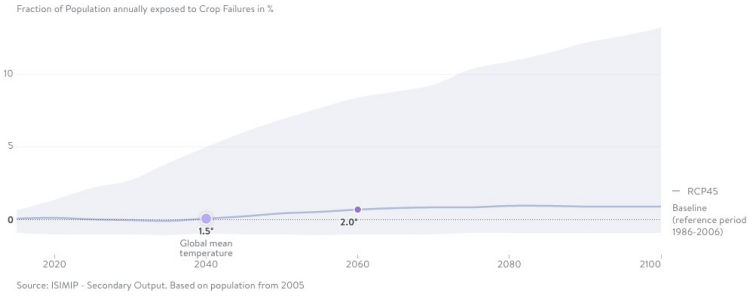

Figure 1(f): Rise in fraction of population annually exposed to crop failure in Meghalaya by 2100 due to climate change (source: https://climateanalytics.org/tools/)

There are various aspects of climate change which makes the above attributes of Meghalaya vulnerable to it. First, rising temperatures due to climate change has led to increased evaporation, untimely rainfall and alteration in rainfall's intensity (it is to be noted that there has been a decline in winter rain). This has led to drying up of mountain springs as well as lakes. Second, melting glaciers as well as increase in extreme events like cloudbursts has led to rise in waters in rivers, which in turn has led to increasing instances of flooding. Third, forest fires have been a natural phenomenon; however, rise in temperatures has acted as a catalyst to increase the spread of forest fires. This has led to increase in damage to the vegetation as well as the wildlife of the forests. Fourth, alteration in average temperatures as well as untimely rain has impacted the biodiversity in a negative manner as the biodiversity of the region has not adapted to the new temperatures. Fifth, due to overall decline in rainfall, large parts of the region have become degraded (as agriculture is the main occupation in the region). Land degradation has also been caused by soil erosion, which is occurring due to increased flooding. Also, climate change induced high frequency of rainfall events is further exacerbating acidification which is leading to decrease in quality of soil.

Threats to Bamboo Drip Irrigation system due to Climate Change

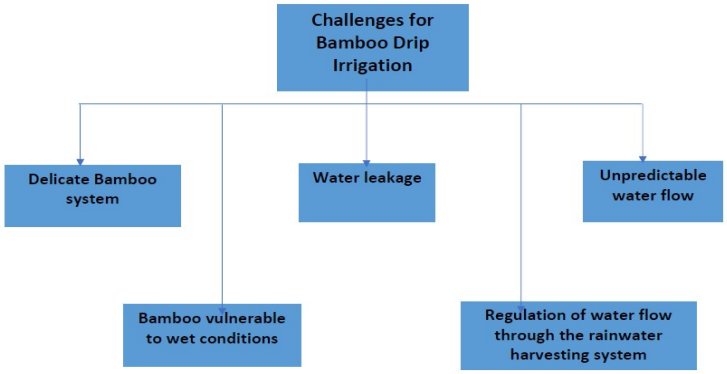

Figure 2: Challenges to Bamboo drip irrigation due to climate change

The 200-year old traditional bamboo drip irrigation system now faces certain set of challenges due to the rapidly changing climate. First, the perennial streams, due to possible extreme events, will experience unpredictable water flow. Water flow can reach minimal level due to rise in temperatures and resultant rise in evaporation, as well as long periods without rain. There can also be a flood like situation due to cloudbursts. Second, rise of extreme events like cloudbursts, forest fires etc threaten the delicate bamboo drip irrigation system. Third, climate change is leading to rising water scarcity. Thus, it becomes more urgent to address the issue of water leakage from the bamboo pipes. Fourth, bamboos are vulnerable to wet conditions and intense rainfall in future due to climate change may require replacement of bamboo strands at short intervals which may increase the maintenance cost and labour engagement. Fifth, regulation of water amount within the rainwater harvesting system will also be challenging. This is due to the possibility of unpredictable water flow in the streams.

Adaptation Strategies for Bamboo Drip Irrigation System

Adaptation Strategy	What is it	Challenge addressed	How does it address the challenge
Riparian Buffer	It is a vegetation wall (grass, shrubs and trees) to be built on the boundary of the stream.	Unpredictable water flow	The Riparian buffer can address overflow of water in case of extreme events like cloudbursts and prevent floods and wastage of water.
Stone lining	It is a wall of stones which can be built on the boundary of the stream	Unpredictable water flow	Stone lining of the stream can address overflow of water in case of extreme events like cloudbursts and prevent floods and wastage of water.
Bamboo walling of streams	It is a wall of bamboo strips which can be built on the boundary of the stream	Unpredictable water flow	Bamboo walling can address overflow of water in case of extreme events like cloudbursts and prevent floods and wastage of water
Inlets of different sizes	Bamboo strands of different sizes for collecting water from the stream	Regulation of water through rainwater harvesting system	Amount of water which is collected from the stream can be regulated according to the need
Building multiple stream access points	Multiple points of water collection from the stream	Regulation of water through rainwater harvesting system	Bamboo drip irrigation system has multiple points of water collection. These points can be strategically decided based on the possible increase or decrease in amount of water in the stream.
Closed pipes	Usage of circular, completely closed pipes instead of semi-circular open pipes	Water leakage	When the water is transferred from one strand to another, due to open nature of the pipes, some percentage of water tends to spill on the ground. There is no scope of water spilling if the pipes are closed.
Water Storage tanks	Above the ground or underground water storage tanks (covered from top) filled with water from bamboo strands.	Regulation of water through rainwater harvesting system	These water storage tanks can be utilised to store excessive water from the irrigation system. Water from these tanks can then be used for household purposes.
Cyclical water harvesting structure	A section of bamboo strands direct excessive water from the irrigation system back to the stream.	Regulation of water through rainwater harvesting system	In case, the water flowing in the bamboo network is more than what is required, some percentage of it can be directed back to the stream. It can, thus,

			regulate water flow and prevent water wastage.
Rubber pipes	Circular rubber pipes in place of bamboo strands for bringing water from streams to the fields	Bamboo vulnerability to wet conditions; delicate bamboo structure; water leakage	Rubber is not as vulnerable to wet conditions as bamboo strands and therefore can be used for a longer period of time. Rubber is also less delicate when compared to thin bamboo strands. Usage of closed rubber pipes (which is normally used in modern drip irrigation system) can prevent leakage of water.
Agro-waste material for inner layering of bamboo strands	Agro-waste material like paddy straws can be used for inner layering of bamboo strands	Bamboo vulnerability to wet conditions	Inner layering of bamboo strands with agro-waste material like paddy straws (which is waterproof in nature) can decrease the vulnerability of bamboo to water.
Wax for inner layering of bamboo strands	Inner layer of bamboo strands can be coated with wax	Delicate bamboo structure; water leakage; bamboo vulnerability to wet conditions	A layer of wax will strengthen the delicate bamboo structure. Wax being a water proof material, can decrease the vulnerability of bamboo to water.
Moving pipes underground	Water once collected from streams can be transported with closed underground pipes	Delicate bamboo structure; bamboo vulnerability to wet conditions	Once the pipes are placed underground, the level of delicacy of the structure does not matter. Also, underground pipes can be saved from the rains and thus, vulnerability to wet conditions will be addressed
Covering parts of stream with direct exposure to sun with bamboo cover	A bamboo shed over sections of the stream where the stream can be under direct exposure to sun or can overflow	Unpredictable water flow; prevent evaporation of water from streams	Preventing the stream from direct sunlight exposure can decrease evaporation of water from the stream to some extent. As the stream will be covered with bamboo, overflow of water into the surroundings can also be prevented.

Table 1: Possible Adaptation strategies for Bamboo Drip Irrigation system

Feasibility of the above adaptation strategies

Quantitative Methodology adopted to calculate feasibility:

- Feasibility score of the adaptation strategy will be calculated out of a score of 100
- Scores under 3 categories will be calculated:
  - Number of challenges addressed
  - Availability, Accessibility, Affordability of the material required to implement the adaptation strategy
  - Fit to culture of the tribal community (whether the material used and the adaptation strategy used is familiar to the tribal community)
- Scoring
  - Total score = 100

- Each category weighs 1/3rd of 100 i.e. a score of 33.3
- Scoring of respective categories
  - Challenges addressed: Total challenges to be addressed are 5. If an adaptation strategy addresses 1 of the 5 challenges, the score allotted to it would be 1/5 * 1/3 * 100 for this category. If an adaptation strategy addresses 3 out of 5 challenges, the score allotted to it would be 3/5 * 1/3 * 100 for this category.
  - Availability/Accessibility/Affordability: The entries in this category and their respective scores will be
    - High > 1 * 1/3 * 1/3 * 100
    - Medium > 2/3 * 1/3 * 1/3 * 100
    - Low > 1/3 * 1/3 * 1/3 * 100
    - N/A > 1 * 1/3 * 1/3 * 100
  - Fit to culture: The entries are in form of Yes or No
    - Yes: 1/3 * 100
    - No: 0 * 100

Data collection for the feasibility table:

- The data for 2nd component (Availability/Affordability/Accessibility) has been derived from government reports.
- Data for 'Fit to Culture' has been derived from interviews of relevant tribal communities. While collecting the data, tribal people belonging to different professions have been approached.

Adaptation Strategy	Challenges addressed	Availability	Accessibility	Affordability	Fit to Culture	Feasibility Score
Riparian Buffer	1	High	High	High	Yes	73.32
Stone lining	1	High	High	High	Yes	73.32
Bamboo walling of streams	1	High	High	High	Yes	73.32
Inlets of different sizes	1	High	High	High	Yes	73.32
Building multiple stream access points	1	High	High	High	Yes	73.32
Closed pipes	1	High	High	High	Yes	73.32
Water Storage tanks	1	High	High	High	No	39.99
Cyclical water harvesting structure	1	High	High	High	Yes	73.32
Rubber pipes	3	Low	Low	High	No	38.51
Agro-waste material for inner layering of bamboo strands	1	High	High	High	Yes	73.32
Wax for inner layering of bamboo strands	3	Medium	Medium	High	Yes	79.25
Moving pipes	2	N/A	N/A	N/A	No	46.66

underground						
Covering parts of stream with direct exposure to sun with bamboo cover	2	High	High	High	Yes	79.99

Table 2*: Feasibility score calculation for adaptation strategies*

Order of Preference according to Feasibility Scores

Preference Order	Adaptation strategy
Most preferred	Covering parts of stream with direct exposure to sun with bamboo cover
2nd Most preferred	Wax for inner layering of bamboo strands
3rd Most preferred	• Riparian buffer • Stone lining • Bamboo walling of streams • Inlets of different sizes • Building multiple stream access points • Closed pipes • Cyclical water harvesting structure • Agro-waste material for inner lining of Bamboo strands
4th Most preferred	Moving pipes underground
5th Most preferred	Water storage tanks
Least preferred	Rubber pipes

Table 3*: Order of Preference according to Feasibility score*

From the above table, it can be noticed that among the 13 possible adaptation strategies for Bamboo Drip irrigation system, covering of stream with a bamboo cover is most feasible and usage of rubber pipes instead of bamboo strands is the least feasible.

Seven Stakeholder Model

Transformation of bamboo drip irrigation into a climate resilient infrastructure by implementing the adaptation strategies is one of the many actions which are relevant in the fight against climate change. Such climate adaptation and mitigation actions require collaboration and coordination among various stakeholders in the development domain. To have the most effective strategy for dealing with climate crisis, these stakeholders need to take individual action as well as supplement the effort of other stakeholders.

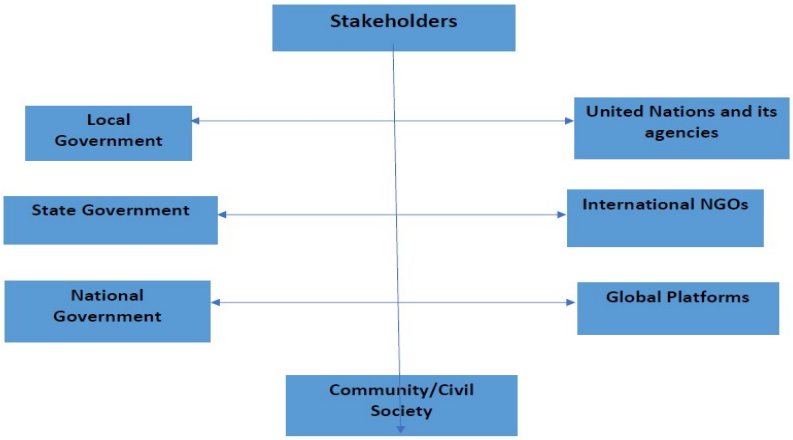

Figure 3: Multi stakeholder approach

Policy Recommendations for Local Government

- Initiating and encouraging discussions on climate change and the need to build climate resilient infrastructure during Gram Sabha meetings. Commit to the decisions taken in Gram Sabha meetings (promotion of decentralised democracy).
- Tie up with local governments of nearby villages to implement projects which can impact both.
- Implementation of mitigation and adaptation projects in a transparent and accountable manner, with regular monitoring and evaluation of projects (where it will be accountable to the Gram Sabha)
- Organise Awareness Campaign regarding climate change in tribal villages.

Policy Recommendations for State Government

- State climate action plan which must include concerns and suggestions of rural/tribal population (bottom-up approach).
- State Action plan on climate change must balance 2 aspects: targets set must be ambitious enough to tackle the climate crisis and targets must be feasible in nature so that they can be implemented timely with limited resources.
- Initiate democratic decentralisation by providing more powers/subjects as well as funds under the local governments.
- Bottom-up approach in design and implementation of projects related to climate mitigation and adaptation as well (considering the suggestions from local level government).

Policy Recommendations for National Government

- Including the concerns of tribal communities in National Climate Action Plan.
- Promoting start-ups which deal with sustainable living in NE India (can be done through Start up India mission).
- Research and promotion of traditional knowledge of resource optimisation. Developing pathways where traditional and modern-day knowledge and technologies can be combined to tackle climate change.
- Skilling of tribal youth which can be done by Skill India (these skills can be utilised for climate mitigation and adaptation programmes).

Policy Recommendations for United Nations

- UN organisations like UNDP, UNEP and UN office for Disaster Risk Reduction can work with state and national government by providing policy insights.
- Tie up with governments across the world to implement their projects on climate adaptation and mitigation.
- Suggest the central government in including tribal community projects in the implementation of Nationally Determined Contributions (NDCs).
- Adding a section of analysis of climate change and its impacts on tribal population of NE India in IPCC reports.

Policy Recommendations for International NGOs

- Policy insights to state and national governments.
- Design, implement own programmes related to climate change in tribal areas.
- Work/collaborate with think tanks to produce relevant data on climate change.

Policy Recommendations for Civil Society

- Ensuring quality education to tribal youth and encouraging participation their participation in efforts to tackle climate change.
- Assistance in form of manpower, technical guidance.
- Promoting start-ups focused on sustainable living in NE India.

Policy Recommendations for Global Platforms

- Facilitate formation of developmental alliance/inter-country grouping on the lines of International Solar Alliance, with focus on tribal population across the world and the challenges they face due to climate change.
- Increasing representation of tribal population of NE India at the global forums like Conference of Parties. This can be done at COP 27 which will take place in Egypt in November 2022.
- Providing experience to tribal youth in sustainable development by facilitating their engagement with global platforms like SDSN youth.
- Formation of a separate platform, within UNFCCC, where tribal people from across the world can meet, discuss their issues and have their declarations.

Conclusion

At present, 80% of the climate action is focused on climate mitigation and 20% on climate adaptation. To tackle the climate crisis effectively, there is a need to balance both climate mitigation and adaptation. As far as bamboo drip irrigation system is concerned, the adaptation strategies discussed in this research paper, if implemented timely, can resolve the issues related to climate change which this traditional rainwater harvesting system is facing in present and will face in future as well. The magnitude of climate crisis is such that governments alone cannot manage it and there is a need for all stakeholders to come on board and coordinate their plan of action to deal with the crisis effectively and in timely manner.

Recommendations for Further Research

Further research can be conducted on:

- Climate change impacts on tribal communities.
- Climate mitigation strategies for tribal communities of Meghalaya.

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