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Mid-term

Summary:

The UN Intergovernmental Panel on Climate Change released a special report that indicated the consequences of a 1.5°C temperature increase above pre-industrial levels within the next few decades. This will lead to Increase in costal countries flooding, Wildfire, Draught which will lead to another consequence as food shortage.

I am going to advice my home country India to minimize the effects of climate change.

Table of Content:

Introduction:

What is climate change?

According to IPCC the definition of Climate change is

"Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity." [1]

In short, the climate change can be described as change in state of atmosphere over time, the cause can be Manmade or natural process of earth. For example, Deforestation, over use of Fossil fuel, Emission of Green house gasses which causes the thinning of Ozone Layer which protects the Earth from harmful ultraviolet rays.

But most of the scientists agrees that the current global warming trend is due to human expansion of greenhouse effect, which happened when the heat is trapped by the earth's atmosphere [2]

Impact of Global warming over the world:

Global climate change effects can already be seen. We see headlines everyday about the change in pattern of weather around the world. The icecaps are melting, Middle east is getting less rain each year, lack of rain leading to Draughts in some countries, accelerating sea-level rise, some countries are losing their agriculture because the weather pattern has become unpredictable, costal countries and islands are flooding; people are literally migrating from their home countries.

In **Canada** Over the period 1948 to 2013, the average annual temperature in Canada has warmed by 1.6 °C, a higher rate of warming than in most other regions of the world. The temperature of Spring and winter has increased which has contributed to the warming trend in Canada the most than any other season. [3]

In **Australia**, Scientists expect climate change will cause changes to geographic range of many species, by restricting or altering species movement and disturb their lifecycles (such as the timing of germination). Climate change presents a biosecurity risk for Australia's ecosystems by altering the distribution of pest and weed species, moreover, Ecosystems have a limited capacity to manage these multiple pressures compared to human systems. The rate of climate change is limiting the capacity of these species to adapt or to migrate in more suitable area. As a result, this species may go extinct.

The recent decrease in rainfall across southern Australia, at an agriculturally and hydrologically important time of the year, is associated with a trend towards high atmospheric pressure in the region.IN crease in draught has also affected the agricultural yield in southern Australia, the forestry is also facing the high risk of declining productivity and tree mortality due to reduction in rain. [4]

Climate change is affecting the **Middle-east** in worst ways. Increased in severe storms, extensive draughts, extreme heat waves are reducing the agricultural area and increasing the unlivable area. Many important waterways of merchant navy pass through Middle East and North Africa. Rise in sea level and changing weather pattern will affect the ports (like the Suez Canal, Turkish Straits, Strait of Hormuz and Strait of Bab al-Mandbab) in these countries. The region is the most "food import-dependent in the world" and more than one-third of all basic foods travel through one of those chokepoints. [5]

A study, published in the journal Nature, found that temperature change due to global warming will leave global GDP per capita 23% lower in 2100 than it would be without any warming. The study breaks down productivity into agricultural and non-agricultural fields. The estimated rise in temperatures will not affect the world evenly. Productivity peaks when temperatures in each region average 55ºF (13ºC), it means that the global warming may increase productivity in cold northern countries while devastating the tropics. That means climate change could also worsen global inequality. [6]

"Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time."

- Intergovernmental Panel on Climate Change

Impact of Climate change in India:

Agriculture:

Just like any other developing country, India depend heavily on agriculture, the effects of global warming on productive croplands are likely to adversely affect both the welfare of the population and the economic development. Tropical regions are particularly more vulnerable to potential damage from environmental changes because the poor soils that cover large areas of these regions already have made much of the land unusable for agriculture.

Rising temperatures and lower rainfall at the end of the growing season have caused a significant loss in India's rice production. Without the effect of climate change, average rice yields could have been almost 6% higher (75 million tons in absolute terms). Observations show that extremely high temperatures in northern India (above 34°C) have had a huge negative impact on wheat yields, and rising temperatures can only aggravate the situation. [7]

Sea-level Rise:

Evident suggests that sea-level rise will increase multidimensional poverty in developing nation. It is estimated that Mumbai and Kolkata are going to be some of the largest population exposure to coastal flooding in 2070. [8]

Changing Rainfall Patterns:

1.5 C global temperature rise is affecting India's rainfall pattern heavily. There is decline on rainfall in some places and some places are getting flooded by heavy rain. Abrupt change in monsoon can precipitate major crisis, can trigger more frequent draughts and flooding in different part of India.

Droughts:

Since 1970 the whole south Asia is becoming drier with major increase in draughts. Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production [9]

Health:

Increasing malnutrition and related health disorder like child stunting are vastly affecting poor people. Malaria and other vector borne diseases, along with and diarrheal infections which are a major cause of child mortality, are likely to spread into areas where colder temperatures had previously limited transmission.

Heat waves are likely to result in a very substantial rise in mortality and death, and injuries from extreme weather events are likely to increase.

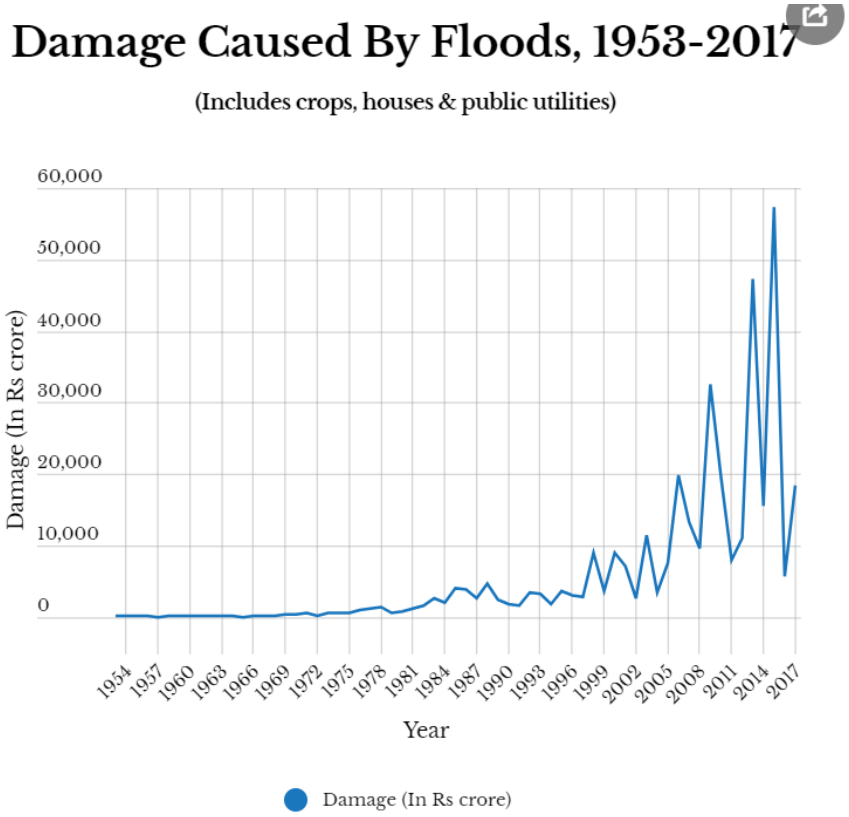
Air pollution in Delhi had become a major issue for Indian government. Visibility has plummeted, and a health emergency has been declared, School had been shut down.

In 2016, NGO **Germanwatch** estimated that India suffered direct infrastructural damage of about USD 21 billion due to extreme weather events, equivalent to almost 1% of India's total GDP – and about the same it spends on the entire health budget.

Global climate change and increased climate variability will have worse impact o human health in India due to the fact that India as a developing nation has resources constrained, high rate of endemic infectious disease and substantial inequality in heath care access as more than half of it population lives in village.

Global climate change and associated increases in climate variability will have severe implications for human health with disproportionate effects on countries such as India, which already face significant public health and health care delivery challenges including resource constraints, high rates of endemic infectious disease, and substantial inequalities in healthcare access. Innovative, applied research in low- and middle-income countries is critical in order to characterize these risks

Economy:



[10]

An analytical chapter from the World Economic Outlook of the International Monetary Fund (IMF), highlights some of the damaging macroeconomic impact of weather shocks, particularly for low-income countries like India. The IMF notes that for the median emerging market, growth goes down by 0.9 percentage point in the same year because of a 1-degree Celsius increase from a temperature of 22 degrees Celsius. What is worse is that the output doesn't recover quickly after a weather shock. Even after seven years, the per capita output is lower by 1.5%. [11]

Groundwater:

As we know India is an agricultural country and 60% of its faming depend upon ground water. Change in rainfall pattern and increasing draught has decreased the ground water level and making it harder to recharge

Glacier Melt:

Glaciers in northwest Himalayas and Karakoram range are significantly the hotspot of global climate change. Himalayan glaciers are the source of many of world's greatest rivers. Like the Yangtze, the Ganges, the Indus and the Mekong. Over a billion people depend directly on the Himalayas for their survival, with over 500 million people in South Asia, and another 450 million in China completely reliant on the health of this fragile mountain landscape. Climate change is causing serious threat to these rivers with a far reaching impacts on biodiversity, food, and energy security. [12]

Energy and water Security:

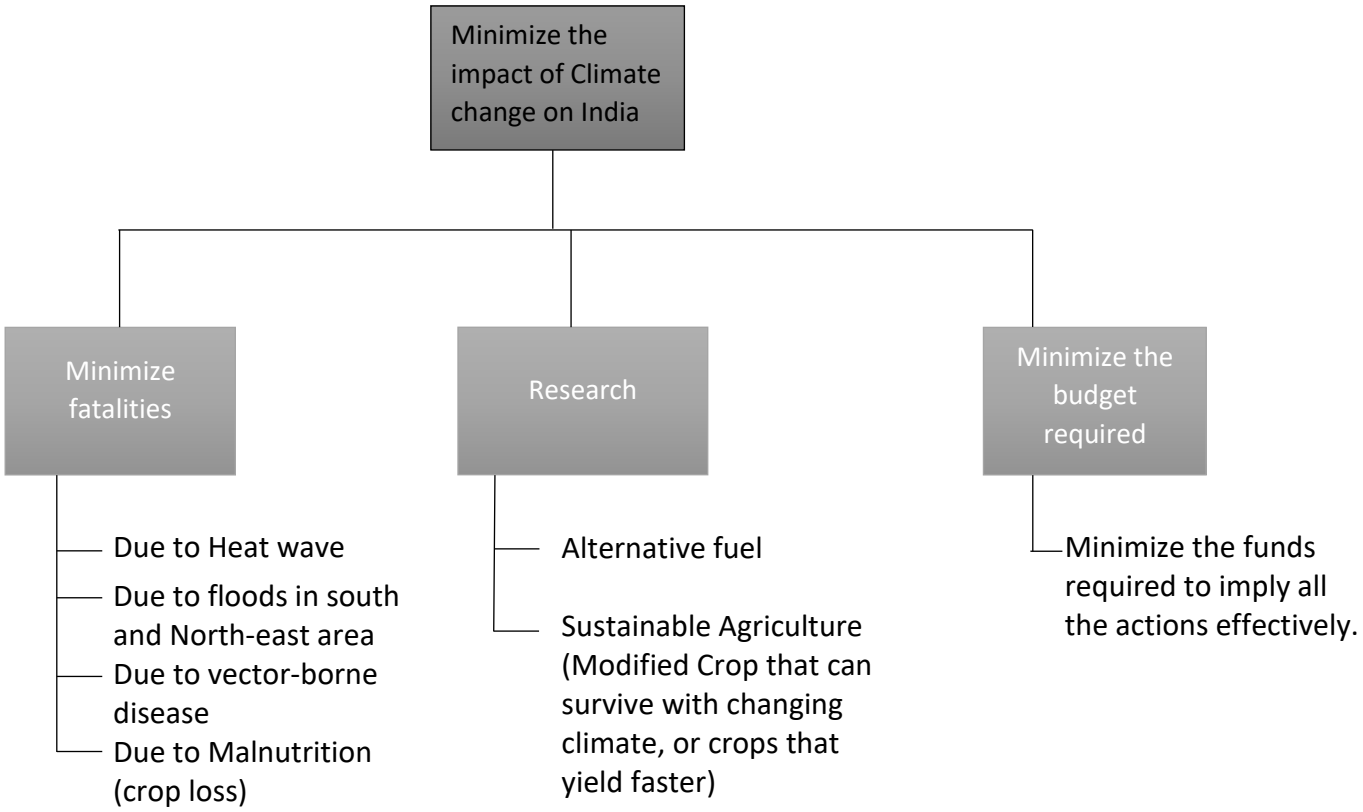
Climate change impacts the water resources and it is indirectly affecting the two dominant power generating source in India; Hydropower and thermal power. Both depends on adequate water supplies to function effectively. To function with full efficiency thermal power, need the constant supply of freshwater for the maintain the cooling system. Increase in variability of river flow can cause these two energy security sources and cause physical damage like landslides, flashflood, glacier outbursts, and other climate-related natural disasters. Increase in variability of rainfall can increase water shortage in some areas. [13]

Decision Making:

Context: Develop a recommendation to the Indian government to implement certain policies to mitigate the effect of climate change.

Identification and Explanation of the Fundamental objectives:

Here, our main objective is to develop a recommendation of policy to reduce the effect of climate change. According t me there are 3 fundamental objectives that can help us to reduce the effect of climate change.

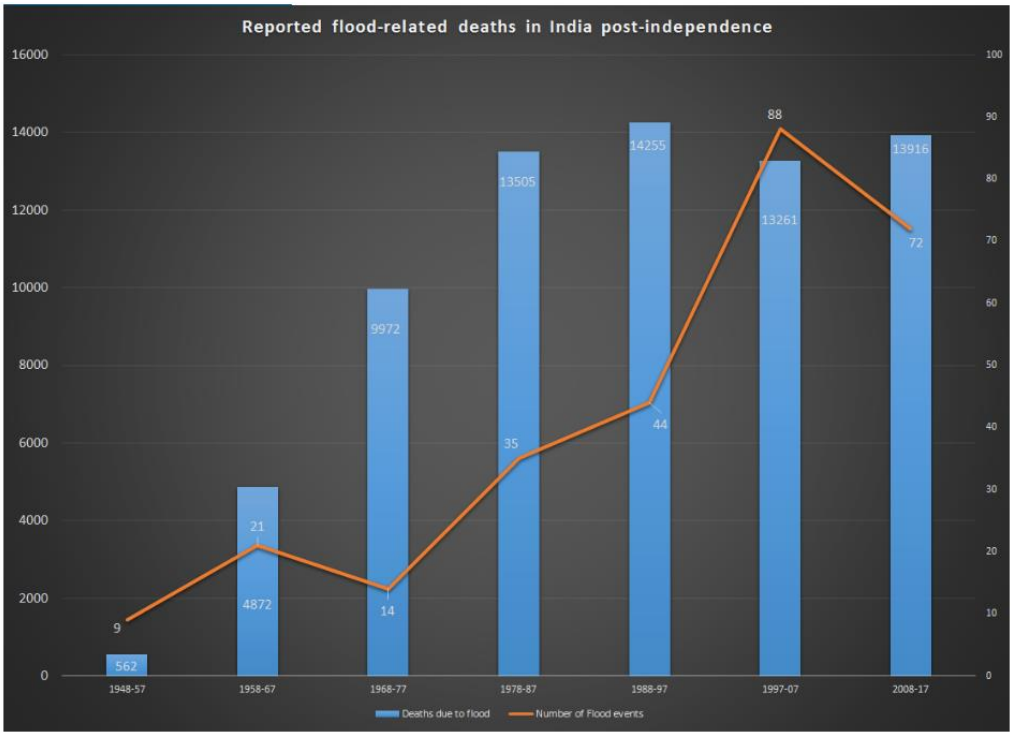


1)Minimizing Fatalities:

This is a fundamental objective because loss of life is the greatest loss. Due to various reasons there are deaths every year Directly-indirectly caused by Climate change. Here, we discuss on how we can minimize the fatalities due to each reason.

- Heat Wave: Average death toll of people dying because of heat wave in India is 4,620.
  How: Provide free freshwater to prevent dehydration, Increasing Plantation for tree shade and parks which can also release the moisture in atmosphere, providing constant electricity (which is a challenge for India) for a hot-climate country, Providing medical facility as priority bases,
- Flood: Year after year the event of flooding and deaths due to floods has increased dramatically.
  How: Relocating people from coastal areas and flash flood prone zones, providing fresh water during flood is important as polluted water can spread disease, develop better forecasting methods, Support and assist people during such tragedy, providing food and roof, running workshop on how to act during such times can save many lives.

A statistic is shown in below graph for floods and related deaths. [14]



- Vector-Borne dieses: Changes in climate lengthens the transmission seasons of important vector-borne diseases and to alter their geographic range. For example, Malaria is strongly influenced by climate.
  How: Providing fresh water to people hit by flood and medical facilities.

- Malnutrition: Climate change is expected to lower grain yields and raise crop prices particularly in developing nations, leading to a 20-percent rise in child malnutrition. [15] . Due to this the poor will be affected as they can't buy food.
  How: Provide mid-day meal in schools for children and underprivileged people.

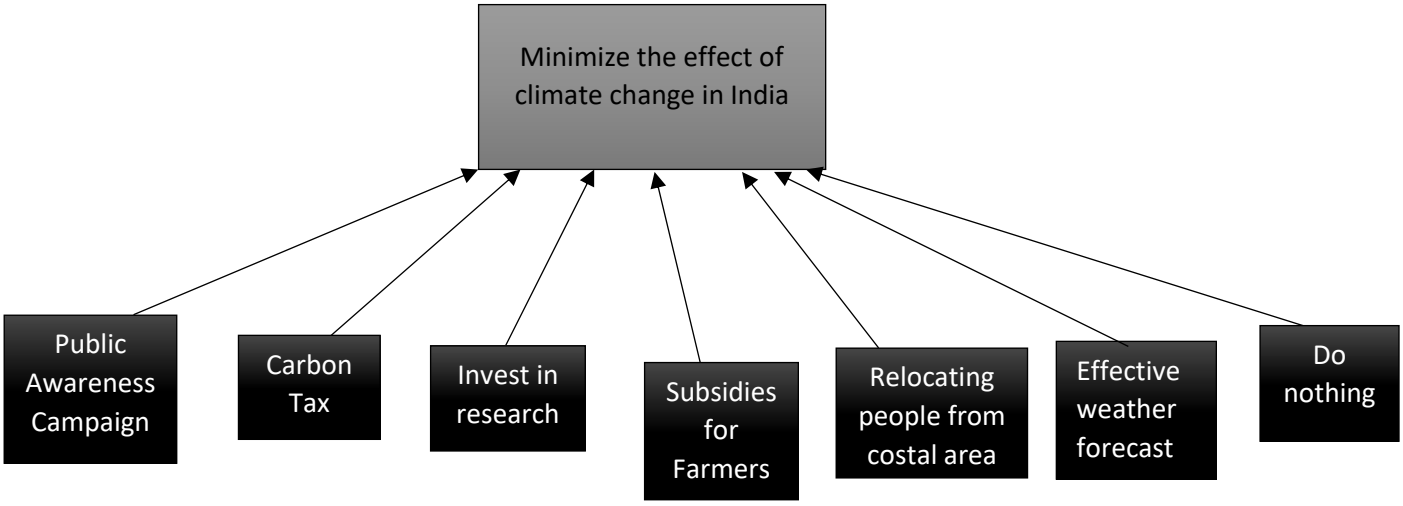
- Health Complications: Over 9 million people in India die each year due to pollution. [16]
  How: Finding alternatives to the fuel we use right now can help minimize this problem.

2) Minimizing the impact of economy: Changing weather pattern and global warming are costing India $9-10 billion annually and it is projected to impact agricultural productivity with increasing severity from 2020 to the end of the century. [17]

3) Minimizing the Budget required: Using the least amount of money to fulfill all activities effectively.

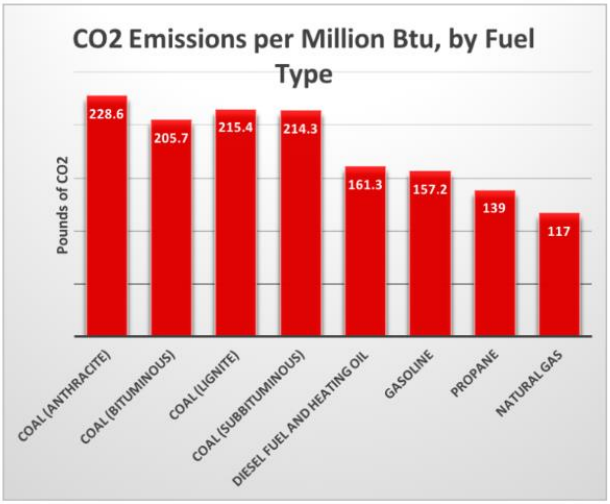
Identification Means Objectives:

Mean objectives helps us to achieve the fundamental objectives. For this recommendation task my mean objectives are as show in following network.



i. **Public Awareness:**
Public awareness campaign for a developing country like India is a useful tool. It can educate people to choose a more sustainable lifestyle. Even I was a member of a program named "Urja Rakshak Dal"; which was run by state government. The goal of the program was to involve students from early age as a responsible citizen and encourage them for energy conservation and run the workshops and campaign of Renewable energy sources to other students and neighborhood community. This way people who haven't been to school can know how climate change can directly affect future of their children.

ii. **Carbon tax:**
For a developing and High population country like India, with current industrialization and rapid modernization rate, it is highly unlikely to reduce the use of conventional energy sources like fossil fuel and coal. So, it is recommended to impose carbon tax, especially for the manufacturing Industries which produce huge amount of carbon waste in to environment. It will encourage them to find alternative source which emits less/ none green-house gasses

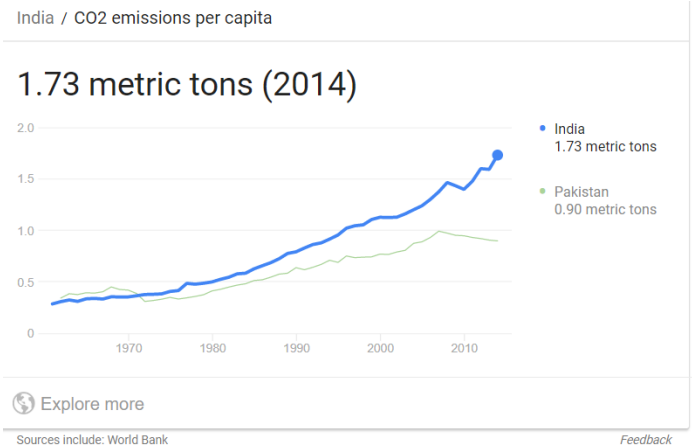


Source: U.S. Energy Information Administration. Coal releases the most CO2, natural gas the least.

iii. Research:

Trying to reduce the effect of climate change is not an overnight thing so investing in long-term research is a still an option here.

- **Alternative fuel:** Alternate fuel like Ethanol, Electricity, Natural gas, Bio diesel, Propane, Hydrogen emits less to none greenhouse gasses. But there is certain limitation of each of these alternatives which makes it hard to implement it commercially. For example, Electricity, to produce it we may have to use conventional fossil fuel and coal which is illogical since we are trying to avoid it. But through research we may find new methods or alternative fuels that can replace existing fossil fuel and coal, to minimize the emission of carbon and greenhouse gasses.



- **Sustainable agriculture**: Putting money to research for agriculture is a good idea for country where 58% people are farmers. [18]
  Investing in to more sustainable agriculture, Hybrid crops (example, perennial crop: is characterized by its ability to regrow after harvest. [19]), Genetically modified crops can also end the question of world hunger and malnutrition in poor countries.

- **Conservation of water:** As the rainfall-days are Decreasing and intensity of rainfall is increasing, most of the fresh/flood water is going to the sea directly. India needs to find a unique way to stop the flood water from getting wasted and conserve it for the warmer season.

iv. Subsidies for farmers:

Helping farmers who have lost their crops due to the variation in pattern of weather, the rain and Extreme heat can help them overcome the loss and keep them motivated. There are additional fatalities (Suicide) of farmers due to crop-loss. [20]

v. Relocating people from coastal area:

This is a good option, but I am not sure it can be implemented. For example, Mumbai, as we know Mumbai floods every monsoon, and it accounts for one-fifth of global deaths due to floods, [21] but still it is impossible to relocate people from there. It is surely over populated city, but people come from far places for job, as Mumbai is Economic Hub of India, it is like New York of India.

vi. Effective Weather Forecast:

It can Reduce the possibility crop-loss and fatalities due to flood and heat wave.

vii. Do nothing:

I am quite sure this is what most of the countries are doing but for the sake of argument this will not help make situation any better, but worse.

Explanation of choice of means objectives:

I have chosen Research on sustainable agriculture, Effective Weather forecast and Carbon tax as my means objective because these three can help us achieve the fundamental objectives the most.

The reason of not choosing Public awareness is that it is a great tool, but people are too ignorant about environmental issue, I as a “Urja Rakshak dal” (Energy guardian) have experienced it.

Subsidies for farmers, wouldn’t impact the fundamental objectives that much. Besides government is already providing subsidies to farmers.

Relocating people from costal area is also not that viable option for a over populated country like India. Besides people are too stubborn they won’t leave their land and business. So it is efficient but not that successfully applicable.

Formulation of Consequence Table:

We take all our fundamental objective as attributes of our consequence table. The nature of all these attributes is uncertain so we take min mode and max for each of the attributes. We also assume triangular probability function for each of them.

I have assumed the values of Economic impact from [22]. Which states that climate change costs 10 billion/year to Indian government. So, all my Values for Economic impact is around that.

For Number of people dying or Fatalities I have assumed values around a million according to this article [23].

And for the Research budget I have used this source for estimating value [24]

Objective	Attribute		Research (alternative fuel and Sustainable agriculture)	Effective Weather Forecast	Carbon Tax
Minimize	**Fatalities (Million)**	Max	3	2	2.7
		Mode	2.1	1	1.5
		Min	1	0.75	0.5
Minimize	**Impact on Economy (Billion USD)**	Max	11	12	9.4
		Mode	9	8.6	5
		Min	5.8	6	3
Minimize	**Budget requirement (Billion USD)**	Max	35	24	19.77
		Mode	26.5	21	16
		Min	18	15.75	12.45

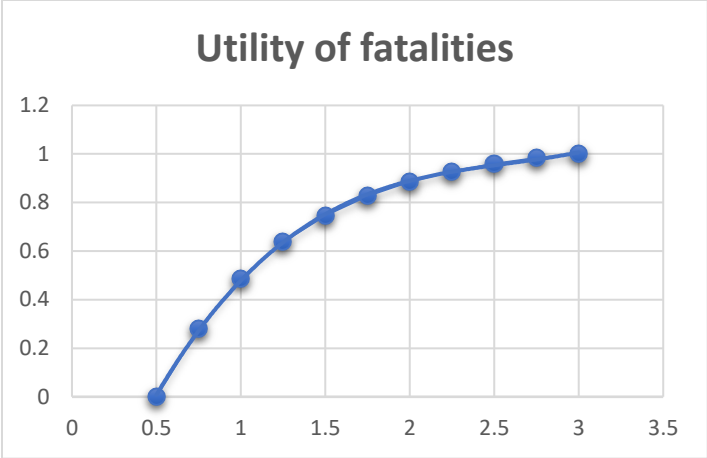
Utility function using Certainty Equivalence:

Minimizing fatality:

Utility of Minimizing fatality U(F):

a+b(1-EXP((-3/0.8)=1 and a+b(1-EXP((-0.5/0.8)=0

we get a= 1.95 and b=-0.908147

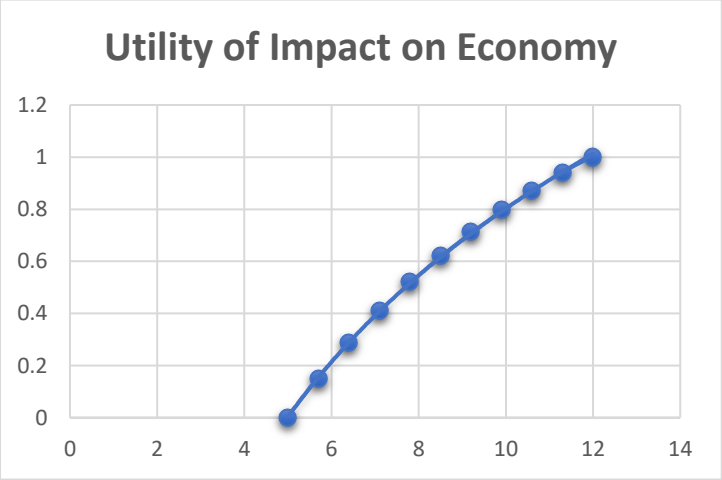


Minimizing Impact on Economy:

Utility of Minimizing Impact on Economy U(I):

a+b(1-EXP((-12/7)=1 and a+b(1-EXP((-5/7)=0

we get, a= 3.23 and b= -1.64957

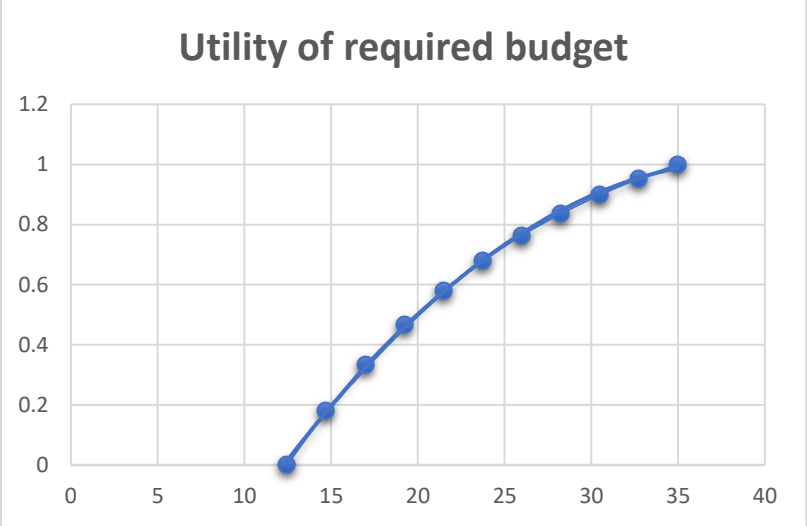


Minimizing Required Budget:

Utility of Minimizing required budget U(B):

a+b(1-EXP((-35/15)=1 and a+b(1-EXP((-12.45/15)=0

we get, a= 2.95 and b= -1.663192



Weight Assessment:

Assessing the Weight of each attribute with the **Swinging weight method**.

	Fatalities	Impact on Economy	Budget requirement	Rank	Rate	Weight
Benchmark	3	12	35	4	0	
Fatalities	0.75	12	35	1	100	0.465116
Impact on Economy	3	3	35	3	45	0.209302
Budget	3	12	12.45	2	70	0.325581
				Total=	215	1

I have given highest weight to minimizing fatality because life is most important amongst all. Budget required to curb this issue is next on the priority list and impact on economy is third.

Expected Utilities Using Monte Carlo Simulation:

Refer Excel File: “SYS660_Midterm_Ekta” for the calculation and Monte Carlo simulation.

Expected Utility = (U(F)* Wf) + (U(I) * Wi) + (U(B) * Wb)

U(Research)= 0.740458089

U (Effective weather forecast) = 0.663654942

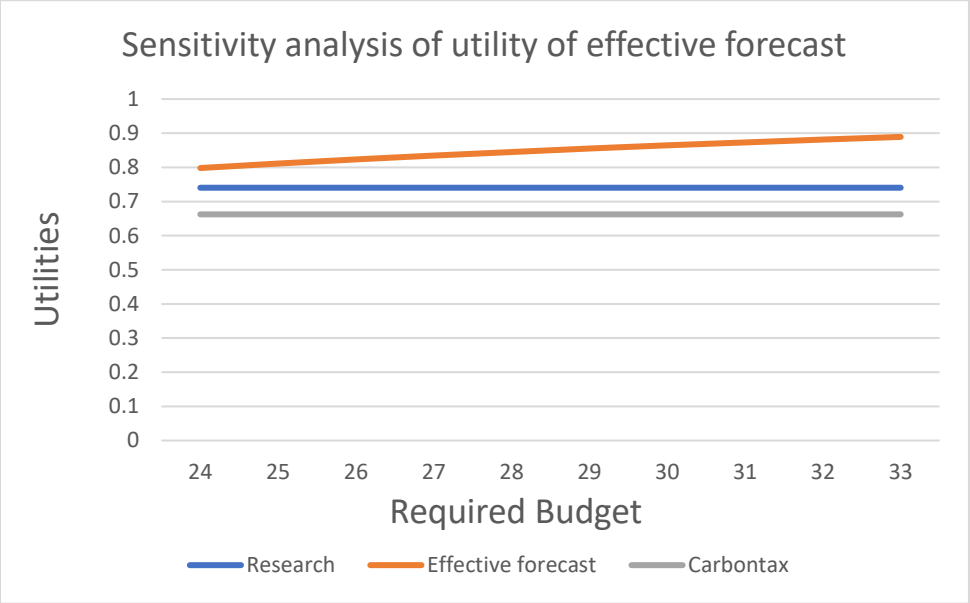
U (Carbon tax) = 0.662424701

Objective	Attribute	Research (alternative fuel and Sustainable agriculture)	Effective Weather Forecast	Carbon Tax
		U*w	U*w	U*w
Minimize	Fatalities (Million)	0.406455763	0.368367577	0.385587457
Minimize	Impact on Economy (Billion USD)	0.13515445	0.138743391	0.122893772
Minimize	Budget requirement (Billion USD)	0.198847875	0.156543974	0.153943471
		0.740458089	0.663654942	0.662424701

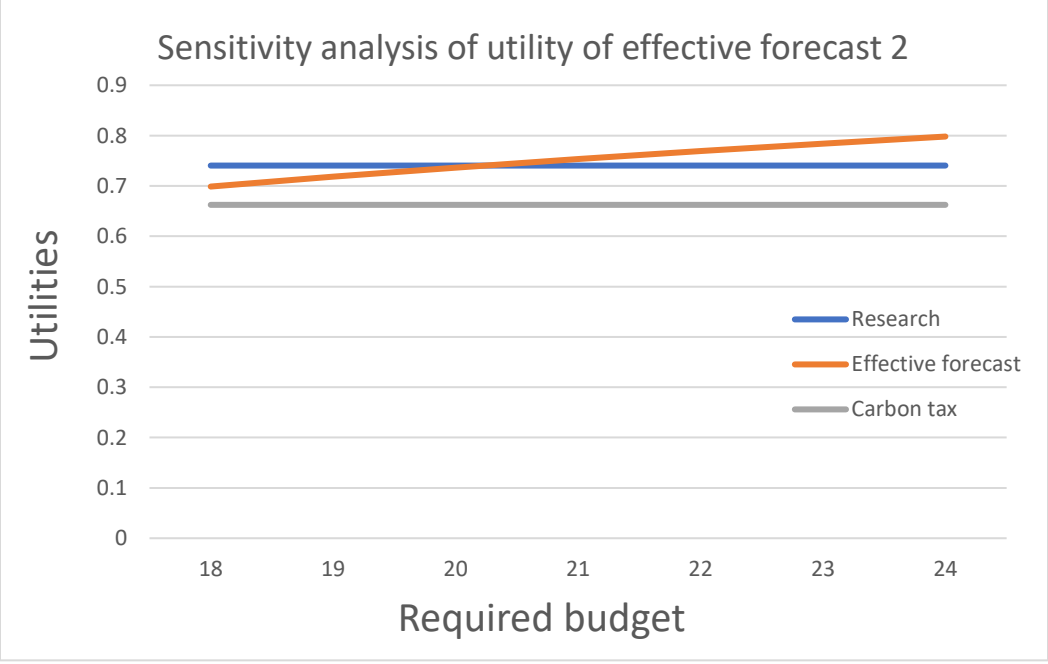
Meaning: As we can see the Utility of Research is highest amongst three This should be the best alternative to invest and will be most effective if future to minimize the impact of climate change, research being an ongoing and long process it is not bad idea because Climate change is also a slow and ongoing calamity. We can also notice that there is not much difference between utilities of Effective weather forecast and Carbon tax. Both have a high value. We can apply these both as well for better results.

Sensitivity analysis:

We change the Required budget attribute for effective forecast and the change in utility can be seen in graph below.

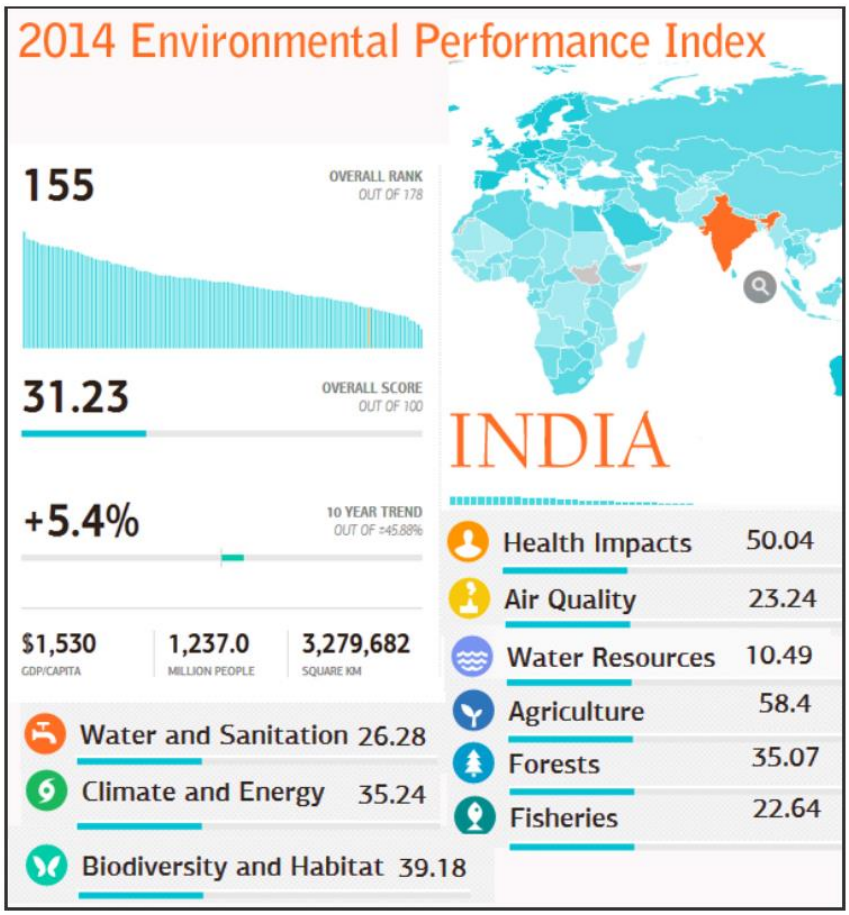


When we change Required budget from 20-21, the expected utility of effective weather forecast overtakes research. So, if the mode of budget requirement is more than 21 then effective forecast can be chosen over research.



Final Recommendation to the Government of India on Minimizing the Impacts of Climate change

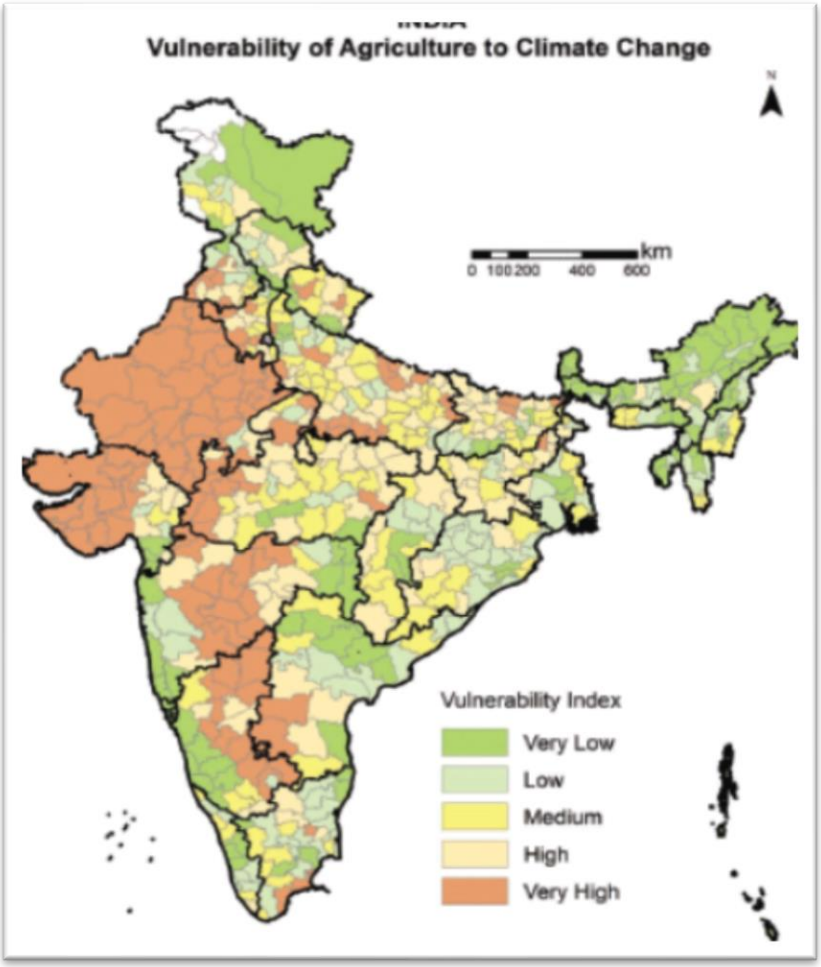
India is a vast country with great atmosphere difference in different part of country and biodiversity. Climate change effects in India are different in different regions.



[25]

Southern and North-Eastern part of India is more impacted by Floods and storms, while Middle and Middle eastern parts are facing rising temperature.

Agriculture and climate change in india:



[26]

As shown above, agriculture in some parts are highly affected by climate change.

- Investing in to **sustainable agriculture research**, keeping in mind these areas and what kind of farming is done here and what kind of crops grown here, will be a well spent money on research for
- Implying heavy **carbon-tax** is also an effective solution. That way people and industries will be encouraged to use more sustainable energy sources like Solar energy hydropower and Wind powered electricity. Solar energy is abundant for India. India being a Warm country with most of the sunny days in year, moving towards Solar energy is a more effective option. So, carbon tax can reduce the pollution and rising temperature in India.

Sources:

[1] https://www.ipcc.ch/publications_and_data/ar4/syr/en/mains1.html

[2] https://climate.nasa.gov/causes/

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[5] https://www.middleeasteye.net/news/climate-change-could-make-middle-east-and-north-africa-uninhabitable-526692845

[6] http://time.com/4082328/climate-change-economic-impact/

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[10] https://www.indiaspend.com/india-accounts-for-15th-of-global-deaths-from-floods-as-climate-change-warning-is-sounded-36697/

[11] https://www.livemint.com/Opinion/E3GJKJDGndRkk8z13XohLO/Climate-change-is-going-to-hit-the-Indian-economy-hard.html

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[14] https://www.moneycontrol.com/news/india/data-story-over-75000-deaths-rs-4-lakh-crore-lost-the-cost-of-natural-disasters-in-india-since-2000-2456611.html
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[22] https://economictimes.indiatimes.com/news/economy/finance/climate-change-costs-india-10-billion-every-year-government/articleshow/60113030.cms

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