DEVELOPING AWARENESS ABOUT CLIMATE CHANGE AND CARBON FOOTPRINT AMONG FUTURE TEACHERS THROUGH MATHEMATICS EDUCATION

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Abstract

Climate change affects humans and natural environments today and particularly in the future. Mathematical knowhow is necessary in producing knowledge about climate change, understanding it as a phenomenon and contributing to the climate debate. Therefore, learning mathematics plays an important role in building a climate-friendly world by raising teachers as critical thinkers and students as active citizens and young scientists. Practicing mathematics boosts abstract thinking, which is an essential tool for anyone interested in climate issues. In this study Researcher has tried to develop awareness among B.Ed. students as future teachers through solving mathematical word problems based on climate change and carbon footprint with a hope to spread this awareness in secondary school students in future.

Keywords: climate change, carbon footprint, mathematics education

Introduction

The world is facing an energy crisis, partly driven by Putin's war since the path to minimize the climate crisis demands that we all use less energy. One place where we can help is by changing the way we eat. Less meat & eating local are often highlighted, but cooking is another big one with carbon footprint of 500 million tones a year , only slightly below the 800 contributedby transporting food. Energy efficient cooking like Bhel, Matki Bhel, Sprout-Bhel, Jhal Mudi, Pant bhat, Bhate bhat came up in Gujrat, Maharastra, Orissa, West Bengal long before.

Scientists discovered the first signs of climate change already over 100 years ago, and ever since then knowledge of climate issues has increased and become more accurate.

However, there has been a delay in developing mitigation strategies. This indicates that scientists alone can't fix the problem, but solving it requires participants from all walks of life.

Learning mathematics boosts abstract thinking, which is an essential tool for anyone interested in climate issues. Weather and climate form a complex system affected by ever-changing conditions of the atmosphere, oceans, glaciers and land. The climate of a specific place is determined by the average weather conditions over a long period of time.

Climate is about weather statistics and therefore climate change is a statistical phenomenon, the effects of which are seen in the world around us. Thus climate science requires large-scale application of mathematics. Predicting future climate requires mathematical modelling with differential equations and reliable quantification. These models are useful for decision-makers, businesses and active citizens pondering action over climate change mitigation. A Carbon footprint is the total amount of CO2 emissions produced, as a result of an individual's actions over a set period of time generally over the period of a year. Whenever an individual drives a car, heats their home, or buys food and other goods a certain amount of carbon dioxide is produced as a result of the manufacturing, fuel extraction, or transportation. The carbon footprint includes both direct and indirect sources of emissions direct being emissions attributed directly to an individual and indirect being carbon dioxide created by a country or production process, attributed to a person living in that country. Generally the amount of carbon dioxide is represented in mass units of some kind, such as kg. The major contributors to carbon footprints are: food, consumption, transportation, and household energy. Food is a major contributor to carbon footprints, and meat in particular is an issue. Livestock is responsible for a significant amount of greenhouse gas emissions, and beef is one of the biggest contributors. One kilogram of beef has the same amount of emissions as driving your car about 160 miles. Completely eliminating meat is not necessary, but reducing meat intake helps lower your carbon footprint. Transportation of foods, pesticide use, and purchasing food out of season also contribute to carbon footprints. Processed foods have higher emissions than fresh food as it includes transportation, production in factories, and additional packaging.

Distribution of Global Carbon Footprint: Carbon Footprint (CF) is another term used for GHGs or carbon dioxide emission in terms of CO2 equivalents. The most recognized definition was proposed by Wiedmann et al.: the CF is the measure of carbon dioxide

emissions directly or indirectly caused by an activity or accumulated over the life stages of a product

Sectors	%
Energy Supply	26
Industry	19
Forestry	17
Agriculture	14
Transport	11
Buildings	8
Aviation	2
Others	3

Home energy consumption is a major contributor, as energy inefficient homes waste significant amounts of energy through poor insulation, energy inefficient appliances, drafts due to improper sealing, and excessive water use. A main contributor within the home is poor insulation, as heat leaves the house quickly. Consumption, including clothing, footwear, and household and personal goods all account for a significant amount of an individual's carbon footprint because these items all have associated emissions from gathering materials, production, and transport. In addition, many know that transportation significantly contributes to a carbon footprint simply because driving cars is polluting. Group transportation like trains or buses pollute less per person, but still have emissions that are associated with them

Need and Importance: Climate knowledge is embodied in texts, diagrams and charts. Communicating this complex information within the scientific community and among decision-makers, planners and the public requires an audience with mathematical literacy. Thus communicating climate knowledge requires mathematical skills within both the producers as well as the consumers of this knowledge. Mathematics is needed for describing and projecting changing climate and communicating those findings. In order to describe the changing climate, we need to know first of all what is "normal". For this, we have to calculate environmental measurements concerning temperature, rainfall, snow cover, sea level, amount of carbon dioxide in the atmosphere etc. By calculating averages, analyzing variance and making diagrams, we can find out whether the climate has changed and how. Mathematics is the cradle of all creations, without which the world cannot move an inch. Be it a cook or a farmer, a carpenter or a mechanic, a shopkeeper or a doctor, an engineer or a

scientist , a musician or a magician, everyone needs mathematics in their day-to-day life. Even Even insects use mathematics in their everyday life for existance . Snails make their shells, spiders design their webs, and bees build hexagonal combs. There are countless examples of mathematical patterns in nature's fabric. Mathematics is a methodical application of matter.

Statement of the study: Developing awareness about climate change and carbon footprint among future teachers through mathematics education

Objectives of the study

- To enlist the important terms related to climate change and carbon footprint to future teachers
- To explain the significant meaning of these terms related to climate change and carbon footprint to the future teachers
- To Formulate the set of mathematical examples based on climate change and carbon footprint
- To ask the future teachers to solve the set of mathematical examples based on climate change and carbon footprint
- To develop awareness about climate change and carbon footprint among future teachers through mathematics education

Methodology: In initial phase of the study researcher orient the B.Ed students about climate change and carbon footprint by explaining related terms with their meaning. Based on this knowledge different mathematical word problems were formulated and given to future teachers to solve and practice. For further retention some brainstorming questions were asked to students for critical thinking. Based on mathematical calculations an orientation was given to the students reducing carbon footprint with simple changes that can be implemented over time. Some of them are given here in tabular form. Some Questions for discussion are also given below

Is nuclear power a global warming solution? **How to mitigate cause of global warming?**

A carbon footprint is defined as the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).

When you drive a car, the engine burns fuel which creates a certain amount of CO2, depending on its fuel consumption and the driving distance. When you heat your house with oil, gas or coal, then you also generate CO2. Even if you heat your house with electricity, the generation of the electrical power may also have emitted a certain amount of CO2. When you buy food and goods, the production of the food and goods also emitted some quantities of CO2.

An individual's carbon footprint is the sum of all emissions of CO2 (carbon dioxide), which were induced by your activities in a given time frame. Usually a carbon footprint is calculated for the time period of a year. If a person's car consumes 7.5 liter diesel per 100 km, then a drive of 300 km distance consumes 3 x 7.5 = 22.5 liter diesel, which adds 22.5 x 2.7 kg = 60.75 kg CO2 to your personal carbon footprint.

Glossary of the terms on climate change and carbon footprint with their meaning

Terms	Meaning
Global warming	A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs & other pollutants.
Climate change	Climate change is any significant long-term change in the expected patterns of average weather of the whole Earth over a significant period of time.
Carbon footprint CF	The amount of CO2 released into the atmosphere as a result of the activities of a particular individual, organization, or community. The CF is the measure of carbon dioxide emissions directly or indirectly caused by an activity or accumulated over the life stages of a product.
Renewable energy	Energy from a source that is not depleted when used, like wind or solar power.
Sustainability	Avoidance of the depletion of natural resources in order to maintain an ecological balance.
Energy efficiency	Energy efficiency is the goal to reduce the amount of energy required to provide products and services. Insulating a home allows a building to use less heating & cooling energy to achieve and maintain a comfortable temperature.
Nuclear power	Electric or motive power generated by a nuclear reactor.
Sustainable dev.	Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

The best way is to calculate the carbon dioxide emissions based on the fuel consumption. Below is a table with the solution to mathematical problems based on sea level rise and carbon emissions:

Situation based on sea level rise & Greenhouse gas emissions	Mathematical function	Word Problems	Solutions (Answers)
As global temperatures increase, water expands. This means that the volume of the world's oceans will steadily increase in time. This causes the sea level to increase. Also, some areas of the world are still changing after the enormous weight of the ice sheets from the last Ice Age have gone away. This causes land areas to rise, and so in those coastal areas, such as the East Coast of North America, sea levels are falling.	A simple function that models the average sea level around the world is given by $H(X) = 0.21X - 401.1$ where X = the year 2012 H = the sea level change since 1910 in cm	What was the change in sea level by 2012? -------------------------- Compared to 2012, how much higher will it be in the year 2100 according to this model? ------------------------ What does this model predict as the carbon dioxide abundance in the year 2012? --------------------------------- What does it predict for the temperature change in 2000 and in 2050 *Reference: Data taken by tide gauges at these locations since 1900.*	In 2012, $H(2012)$ = 21.3 cm. ------------------------ $H(2100)$ = 40.0 cm. The increase will be about 40 cm - 21.3 cm = 18.7 cms ie about 7 inches ---------------------- X = 2012-1990 = 22, so P(22) = 392 PPM. Students may graph this function and look for the solution where P(X)= 392 x 1.5 = 588 ppm. ------------------------ --For 2000, X = 4 decades, so T(4)= +0.45 Celsius. For 2050, x=9 decades T(9)= + 0.95 Celsius.

Brainstorming questions

Human emissions of CO2

- Finland´s greenhouse gas emissions were 60.1 million tonnes of carbon dioxide (CO_2 eq). That was 5% less than in the previous year. If the emissions continue to decrease at a similar rate, how much carbon dioxide will Finland will produce in 2050?

- Human emissions of CO_2 are 10 Gt per year. Write a linear equation for emissions going down to zero by 2050.

- Human emissions of CO_2 are 10 Gt per year. What is the percentual decrease in emissions if it were to be 1Mt by 2050?

- If emissions increase by 2% per year, what would be the total amount of emissions over the next two years? Use integration to calculate the result.

- Q. What makes your car go: When 2 molecules of gasoline (ethane) are combined with 7 molecules of oxygen you get 4 molecules of carbon dioxide and 6 molecules of water.
- Q.What is the ratio of ethane molecules to water molecules?
- Q. What is the ratio of oxygen molecules to carbon dioxide molecules?
- If you wanted to 'burn' 50 molecules of ethane, how many molecules of water result?
- If you wanted to create 50 molecules of carbon dioxide, how many ethane molecules would you have to burn?

Reducing carbon footprint with simple changes that can be implemented over time.

- Take **reusable** cloth or canvas grocery and produce bags to the store. Avoid single-use containers. When that isn't possible, try to buy food packaged in paper, cardboard or glass. Carry **reusable** water bottles, takeout containers and straws with you when you're on the go.

- Using sustainable transport whenever possible. Walking or riding a bike can completely avoid carbon emissions from driving. The production of shoes and a bicycle contributes to carbon emissions. Using public transportation can drastically reduce carbon dioxide emissions. Low carbon vehicles are an option available that allow driving but reduce carbon emissions overall. Electric cars emit no carbon dioxide if the electricity they're charged with has no associated carbon emissions.

- Drive more efficiently by not speeding and accelerating unnecessarily, as these driving styles can reduce mileage by 33%. Also, avoiding traffic whenever possible is important as idling contributes to CO_2 emissions.

- Improving home energy efficiency by insulating and sealing it properly. Utilize weather stripping and caulking to ensure windows, doors, and skylights do not have air leaks. In addition, using energy efficient appliances especially furnaces, air conditioners, and refrigerators, can reduce emissions that contribute to a carbon footprint. Upgrading incandescent light bulbs to fluorescents or LEDs is also a way to reduce emissions, along with setting thermostats to an appropriate level Recycling and composting helps to reduce carbon emissions associated with the "provision of goods", or the extraction of resources, transport, manufacturing, and disposal of goods.

- Green building is the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's life-cycle from sitting to design, construction , operation , maintenance, renovation and

deconstruction. **Environmental benefits of Green building is it** Enhances, Protect, Improve , Reduce, Conserve and restore . **Economic benefits of Green building is it** Reduce operating costs, Improve productivity, Enhance asset value and profits, Optimize life cycle economic performance. **Social benefits of Green building is it** Enhance health and comfort, Improve indoor air quality, Improve overall quality of life.

- Think about "food miles" by eating locally grown foods. A significant amount of greenhouse gas emissions are produced as a result of producing and transporting food, so the emissions can be reduced by eating food grown close to home.
- Reduce beef and dairy intake, especially if it is not locally produced. The production of beef and dairy on large farms produces a large amount of greenhouse gases.
- Reduce water usage in the home. This lowers the amount of energy required to pump, treat, and heat water. Conservation along with using water saving shower heads, toilets, dishwashers, and washing machines can help here.

Discussion: Mathematical information is at the heart of communicating, predicting, and working with issues related to climate change. The consideration of social and economical values in relation to mathematics education and issues of climate change thus provides us with an understanding of the interrelationship between mathematics education and social, economical and ecological worlds around us, in a broader sense. By enabling B.Ed. students to critique with mathematics in the classroom, and by integrating moral and ethical questions in a non-normative way, mathematics teachers can help students evolve as critical citizens to reflect on the different challenges of climate change and to become active participants of democratic societies. Although including climate change and carbon footprint in mathematics classrooms can be viewed as an ethical responsibility of mathematics teachers, in their day-to-day practice.

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