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AGRICULTURAL MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN NIGERIA: AN OVERVIEW

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Abstract- In this paper we put forward a hybrid stacking ensemble approach for classifiers which is found to be a better choice than selecting the best base level classifier. This paper also describes and compares various data mining methodologies for the domain called employment prediction. The proposed application helps the prospective students to make wise career decisions. A student enters his Entrance Rank, Gender (M/F), Sector (rural/urban) and Reservation category. Based on the entered information the data mining model will return which branch of study is Excellent, Good, Average or poor for him/her. Various data mining models are prepared, compared and analyzed.

Keywords- Confusion matrix, Data Mining, Decision tree, Neural Network, stacking ensemble, voted perceptron

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Introduction

Nigeria as a Nation

According to United States Central Intelligence Agency World Fact Book, Nigeria is a country in West Africa around geographic coordinates of Latitude 10^0 00'N and Longitude 8^0 00'E. It has a total area of 923,768 square kilometers, coast line of 853 kilometers and total land boundary of 4,047 kilometers with irrigated land of 2,930 square kilometers. The total renewable water resource is 286.2 cubic kilometers, while total freshwater withdrawal is 8.01 cubic kilometers per year. Nigeria climate is largely equatorial in the south, tropical in center and arid in the north. The terrain is southern lowland merge into central hills and plateaus; mountains in southeast and plains in the north. Arable land use is about 33%. Nigeria has 36 States and a central capital (Abuja) as the government headquarters. Nigeria faces environmental issues like drought, flooding, soil degradation, rapid deforestation, urban air and water pollution, desertification, oil spill, rapid urbanization and loss of arable land. Nigeria is with a population of over 150 million with diverse ethnic groups and languages [41].

Nigeria obtained independent from Britain in 1960 and runs democratic system of Government with upper and lower houses of parliament [41]. Nigeria is a developing economy having around US$30-50 billion in foreign reserve. The nominal gross domestic product (GDP) for 2010 was US$216,803 billion while GDP per capital for that year was US$1,389. Crude oil is the main stay of Nigeria economy providing more than 60% of revenue for the government spending annually. Key sectors of the Nigerian economy include the oil industry, agriculture, banking, telecommunications, insurance and others. Nigeria is a desired market for investment because of a population base that leaves many as potential consumers for good products [40]. Nigeria has launched three satellites into space within the last decade. The country is not doing badly in science even though this sector appears more active towards health concerns. Nigeria is advanced in arts in Africa with books, plays, movies and music reaching millions annually. Nigeria actively participates in sporting activities which some say unites everyone during classic competitions. Nigeria is a country with broad prospects economically and scientifically, with works in place and more, the country should close in on all round development in shorter than projected time [41].

Climate Change and Global Warming

Climate change is the changes in weather condition in the past few years caused by global warming. Global warming is increase in the average temperature of planet earth caused by continuous emission of gases that trap heat to the earth's atmosphere [10]. Climate change and global warming are often used interchangeably. In an upper part of the atmosphere called the troposphere 10-19 km above sea level, certain gases trap heat to the earth to make it warm. Without these gases, the average temperature of the earth will be 33^0C colder not able to support life for humans and several living things. These heat trapping gases for their action that resembles heat trapping effect to a glass house called green house gases (GHG) [10]. There are a number of GHG known with some more potent and available than others, these GHG have a natural cycle that keep them balanced and available at certain range in the earth's atmosphere for their function to keep the earth warm. Certain anthropogenic activities like burning of fossil fuels release gaseous products made up of one or more GH gas. These gases stay for a while in the environment, and may escape after a long time by the action of wind to the upper atmosphere. Depending on the kind of gas released, it may be trapped by trees (for gaseous exchange or breathing), it may also be changed in reaction with oxygen available in air, or it may be dissolved in sea water. It takes some time for carbon (IV) oxide to escape to the upper atmosphere from the earth. The GHG available in the atmosphere bracket are carbon dioxide (CO_2), water vapour (H_2O), methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and carbon monoxide (CO). These gases are helpful to us but hold the potential to be harmful in large amounts by our activities. Global warming potential is used to measure their contribution to climate change over a period of years against a standard of 1 representing carbon dioxide potential. With increase in these gases by anthropogenic activity, more heat will be trapped to the earth increasing its average temperature by a fraction in a period of time; this will tilt weather and climate conditions of the earth to an anomalous state. Since 1905, global average surface temperatures have increased 0.78^0C with about 0.61^0C occurring since mid-1970s i.e. about 0.8^0C increase since pre-industrial era. Human activities are said to upset this range causing increase in amounts of GHG emissions; amounts of Carbon dioxide concentration in the atmosphere is around 380 parts per million (ppm) and may increase by more than 50% of this amount in 2050. Around 33 billion tonnes of carbon dioxide emissions was the total for 2010 and 2-3% is the range of annual increase for many decades [41]. Ocean surge, health problems, irregular rainfalls, record avalanche and blizzards, addition to devastation of disasters and more could come with increase in average temperature of the earth according to certain studies [42]. Series of weather deviations have occurred recently in different places on earth; these are linked to earth's average temperature increase or global warming. Nigeria has been witnessing torrential rainfall, massive erosion and desert encroachment among a series of weather aberration.

Ozone Layer Depletion

Ozone Layer depletion has been linked to climate change in several studies, but it is separate from the phenomenon. The ozone layer is a layer of gas present in an upper part of the atmosphere, the stratosphere, which is about 20-48km above sea level. It primarily contains three structurally different forms of oxygen (allotropes of oxygen) constantly reacting in the presence of ultraviolet (UV) light; ozone is however predominant amongst these [39]. In a series of reaction, ozone gas protects planet earth from harmful UV radiations allowing non-harmful UV radiations to pass. Since the ozone layer contains gases in reaction, these gases can enter reaction with other kinds of gases that travel up that altitude [45]. From certain substances used by man, such as aerosols, refrigerants and fire extinguishers, halons and fluorocarbons gases are released. As these gases escape to that level of the atmosphere, they react with ozone molecules forming compounds that cannot protect against harmful UV radiations [39]. This shortage of useful ozone molecules leads to depletion at that level of the atmosphere causing harmful UV radiations to pass. This depletion to a certain degree is known as a hole or the ozone hole. The ozone hole was noticed in the 1970's, its danger prompted moves by nations in the 1980's to agree against use of ozone depleting substances to keep natural repair possible around middle of this 21st century [39]. The ozone layer however and global warming are linked but different. Nigeria either for ozone depletion or climate changes is vulnerable to negative effects of global warming, because of actions of stratospheric winds up in the atmosphere that sweeps gases from one region to another at different times of the year. Nigeria's carbon emission is increasing but is partly tanked by tens of millions of trees in the land. Large volume of vehicles in cities puts carbon emissions up, surged by traffic situations that leave powered vehicles static or in snail moves increasing emission amounts in near atmosphere. Livestock dungs and belches from careless disposal and traditional nutrition respectively increase methane emissions. Power loses from existent means of power generation saves less energy. All these are parts of the sources of emissions in Nigeria. In many African regions**,** the area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. In some countries, yields from rainfed agriculture could be reduced by up to 50% by 2020 [41]. Butt. et al predicted future economic losses and increased the risk of hunger due to climate change. It seems clear the combination of high climatic variability poor infrastructure, economic poverty, drought, excess rainfall, poor livestock health, reduced crop yields, low productivity and a range of other problems associated with climate variability will constitute important challenges for Africa countries in particular [7,8]. Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities [41]. Climate change is also projected by the mid-century to reduce water resources in many small islands especially in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low rainfall periods [41].

Climate Change and Agricultural Adaptation

Adaptation to climate change is the adjustment in natural or human system in response to actual or expected climatic stimuli or their effects [16,32]. Climate change adaptation is increasingly becoming an area of growing interest and engagement for many developing countries that unfortunately bear the brunt of an overheating planet caused by developed countries. The uncertain effects of a changing climate on Nigeria's economy pose significant setbacks for meeting development targets like Nigeria's aspiration to be

among the twenty best performing economies of the world by the year 2020 [Vision 20:20:20] and achievement of the millennium development goals. Adaptation to climate change is a serious problem in the developing nations, especially Nigeria, due to low income and poor technological base [20,29,31-33,36].

Climate plays a dominant role in agriculture by having a direct impact on the productivity of physical production factors including the soil's moisture and fertility [37,44]. Adger W.N. asserted that agriculture places heavy burden on the environment in the process of providing humanity with food and fiber, while climate is the primary determinant of agricultural productivity. Adverse climate effects can influence farming outputs at any stage from cultivation through the final harvest. Even if there is sufficient rain, its irregularity can affect yields adversely if rains fail to arrive during the crucial growing stage of the crops [3,18,23,28,43]. Though climate change is a threat to agriculture and non-agricultural socio-economic development, agricultural production activities are generally more vulnerable to climate change than other sectors [6,9,13,21]. Studies that related climate change to agricultural production in Nigeria are more of general analyses of potential impacts of climate change on crops production, food security and animal husbandry [1,2,4,20,22,24,30]. Ikhatua (2010) shows that in Nigeria and by extension globally, climate change will affect all four dimensions of food security, namely food availability, access to food, stability of food supplies, and food utilization. According to Intergovernmental Panel on Climate Change (IPCC), several adaptation measures that agricultural sector can undertake to cope with the changed climate are (i) changing planting dates according to temperature and rainfall patterns (ii) planting different varieties or crop species, (iii) development and promotion of alternative crops, (iv) developing new drought and heat-resistant varieties, (v) more use of intercropping, (vi) using sustainable fertilizer and tillage practices (improving soil drainage, no-till, etc), (vii) improved crop residue and weed management (viii) more use of water harvesting techniques (changing their crop rotation system to make the best use of available water), (ix) better pest and disease control for crops, (x) implementing new or improving existing irrigation systems (reducing water leakage, soil moisture conservation-mulching), (xi) improved livestock management (providing housing and shade, change to heat-tolerant breeds, change in stocking rate, altered grazing and rotation of pasture), (xii) more use of agroforestry practices, (xiii) improved forest fire management (altered stand layout; landscape planning; dead timber salvaging; clearing undergrowth; insect control through prescribed burning), (xiv) development of early-warning systems and protection measures for natural disasters (droughts, floods, tropical cyclones, etc) and (xv) plant hedgerows or small wooded areas on arable land that reduce water run-off and act as wind-breaks [18]. Nevertheless rural communities in Nigeria have always managed their resources and livelihoods in the face of challenging environmental and socio-economic conditions [27,34]. They have to a large extent been able to develop their livelihood strategies in a way which enables them to constantly cope with and adapt to an erratic climate change, severe pest attack, changing agricultural policies at local, national, global levels and other natural factors [7,11,18,26,35]. There is therefore need to gain as much information as possible, and learn the positions of rural farmers and their needs, about what they know about climate change, in order to offer adaptation practices that meet these needs.

Climate Change and Agricultural Mitigation

Mitigation of climate change is a human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases [18]. Mitigation of climate change is a global responsibility. Mitigation of GHG emissions in agriculture has several approaches: (i) emissions can be reduced; (ii) emissions can be avoided or displaced; or (iii) sinks can be created to remove emissions. Mitigation must be seen in the context of farmers' decision making. For most farmers, it will be a co-benefit whilst increasing agricultural productivity in a climate-smart manner. About 90% of the total mitigation arises from soil carbon sequestration and about 10% from emission reduction. Several farming practices and technologies can reduce GHG emissions and prevent climate change by enhancing carbon storage in soils; preserving existing soil carbon; and reducing carbon dioxide, methane and nitrous oxide emissions [18].

Conservation Tillage and Cover Crops

Conservation tillage is a number of strategies and techniques for establishing crops in the residue of previous crops, which are purposely left on the soil surface. Reducing tillage reduces soil disturbance and helps mitigate the release of soil carbon into the atmosphere. Conservation tillage also improves the carbon sequestration capacity of the soil. Additional benefits of conservation tillage include improved water conservation, reduced soil erosion, reduced fuel consumption, reduced compaction, increased planting and harvesting flexibility, reduced labor requirements and improved soil tilth.

Improved Cropping and Organic Systems

Organic systems of production increase soil organic matter levels through the use of composted animal manures and cover crops. Organic cropping systems also eliminate the emissions from the production and transportation of synthetic fertilizers. Components of organic agriculture could be implemented with other sustainable farming systems, such as conservation tillage, to further increase climate change mitigation potential.

Conservation Tillage Systems for Organic Crop Production

Conservation farming practices not only conserve moisture, improve yield potential but also reduce erosion. Fuel costs also increase soil carbon. Examples of practices that reduce carbon dioxide emissions and increase soil carbon include direct seeding, field windbreaks, rotational grazing, perennial forage crops, reduced summer fallow and proper straw management [6]. Using higher-yielding crops or varieties and maximizing yield potential can also increase soil carbon.

Land Restoration and Land Use Changes

Land restoration and land use changes that encourage the conservation and improvement of soil, water and air quality typically reduce greenhouse gas emissions. Modifications to grazing practices, such as implementing sustainable stocking rates, rotational grazing and seasonal use of rangeland, can lead to GHG reductions. Converting marginal cropland to trees or grass maximizes carbon storage on land that is less suitable for crops.

Irrigation and Water Management

Improvements in water use efficiency, through measures such as

irrigation system mechanical improvements coupled with a reduction in operating hours; drip irrigation technologies; and center-pivot irrigation systems. All these can significantly reduce the amount of water and nitrogen applied to the cropping system. This eventually reduces GHG emissions of nitrous oxide and water withdrawals.

Nitrogen use Efficiency

Improving fertilizer efficiency through practices like precision farming tracking system can reduce nitrous oxide emissions. Other strategies include the use of cover crops and manures (both green and animal), nitrogen-fixing crop rotations, composting and compost teas, and integrated pest management.

Methane Capture

Large emissions of methane and nitrous oxide are attributable to livestock waste treatment, especially in dairies. Agriculture methane collection and combustion systems include covered lagoons and complete mix and plug flow digesters. Anaerobic digestion converts animal waste to energy by capturing methane and preventing it from being released into the atmosphere. The captured methane can be used to fuel a variety of on-farm applications, as well as generation of electricity. Additional benefits include reducing odors from livestock manure and reducing labor costs associated with manure removal.

Biofuels

There is significant scientific controversy regarding whether biofuels-particularly those derived from oilseeds (biodiesel), feed corn (ethanol) or even from cellulosic sources-are carbon neutral. To ascertain the true climate neutrality of biofuels requires a careful life-cycle analysis of the specific biofuels under consideration. Also, an analysis is needed to understand what the global land use change implications will be if farmers grow more of a specific biofuels feedstock.

Soil Carbon Sequestration

This is one of the most promising options with a wide range of synergies. By increasing carbon concentrations in the soil through better management practices, this option offers benefits for biodiversity, soil fertility and productivity, and soil water storage capacity. Further, it stabilizes and increases food production and optimizes the use of synthetic fertilizer inputs, reversing land degradation and restoring the "health" of ecological processes.

Renewable and Sustainable Energy

Sources of renewable and sustainable energy prevalently known are Solar and Wind, the former is used in certain parts of Nigeria for some projects. These on a large scale are very expensive which makes outlook for deployment to cover a wide area around 2016 by the federal government of Nigeria. The United States Energy Information Administration (USEIA) report also puts that by year 2035, world energy demands will increase by 53% and that renewable energy will be the fastest growing sector for electricity consumption. This projection leaves a point to clinch for increasing energy demands within the country even though about 50% of energy supplied to homes is wasted in unused or misused energy [42]. Plans however can be mapped to avoid issues foreseen or sudden the time. Photovoltaic cells development to harness solar for power generation is already at tertiary stage, with research and advances, those to come in 5 years will be more powerful, cheaper and easier to integrate. This puts more hope in this direction for Nigeria despite ongoing plans for power generation with other alternatives. Wind power is also expensive involving several wind turbines in a location expected to be permanent for mechanical or electrical power generation. With Nigeria having thousands of acres of lands along highways connecting states, Wind farms are possible in plans similar to solar cells stated above. Biomass, as a renewable energy project can be started in Nigeria with better constructed landfills and transportation. Biomass worldwide holds a fraction of renewable in power generation but does not stop Nigeria to seek to develop this in a period of rising waste percentage. Biodiesel and Bio-kerosene that are directed at a cheaper and cleaner future could be realized in Nigeria. They are also workable if affordable and uninterruptedly available.

Engine Importation and Carbon Capturing Devices

As a consuming economy, Nigeria relies more on importation for various products especially engine powered devices running on fossil fuels, vehicles, machines, generators for alternative power generation and more. These contribute to Nigeria emission average with possible increase if authorities do not minify clemency available to support or boost trade. Sea and air transport control authorities in charge of importation have their standards, but in these times of carbon economics, emission per time standard for engines should be imputed more to save the nation from 'dumps' exiting other places for possible stay here. This will surely take time and may not take off till about 2016, but plans towards it should start now. Measurements should be increased and warnings with information to create awareness for those involved in like importation should be commenced. This will rid Nigeria of such engines as those in use will fizzle out from around 2020 and beyond. Carbon capture and storage involves separating carbon dioxide from source and transporting it to be stored at a location to avoid release to the atmosphere by isolating it. The location is usually a geologic formation, either deep ocean or underground. Use of this is not strange to some oil servicing companies in Nigeria [17]. Carbon dioxide is important for enhanced oil recovery for oil producing organizations, opening a market for carbon storage close to oil fields. This type of emission cap is expensive but will do well with government support in structure and funds for the long term. Some countries are currently on this and their model can be considered by Nigerian authorities.

Tree Planting Within Cities

Trees within cities have a great advantage to supplement the near environment with more of oxygen after inhalation of carbon dioxide. This is natural 'carbon-capture'. Vehicles are said to produce around 20% of world total carbon emissions. With growing urbanizations in Nigeria and traffic in cities, fast growing plants should be set in soil for growth within cities to help with human health concerns and also cap emissions. Fast growing Malaysian tree (*Albizzia falcata*), grows 10.75 meters in just over a year. Candlenut, a Malaysian evergreen tree (that keeps its foliage round the year) can grow to about 18 meters in a short time too. Broad leaves of banana trees, well-conditioned can trap around 0.0005

part per million by volume of carbon dioxide (CO_2) on a sunny day. These trees will assimilate CO_2 to make their own food when combined with light and water; this will continue through their growth and mature life. Efficacious plants peculiar to our environment and conditions should be maintained around cities to ensure we go green and stay green.

Modern Landfills and Livestock Methane Management

Landfills need to be developed in Nigeria because of their diverse advantages.. Methane from livestock and landfills contribute largely to emission amounts in any country and is important to Nigeria because of her peculiarities. Livestock population in Nigeria has been estimated to consist of 16 million cattle, about 13.5 million sheep, some 26 million goats, approximately 2.2 million pigs and 150 million poultry animals [14]. Many of the nomadic herdsmen up north and down south have minute (if any) knowledge of what harm decomposed dung of their cattle can cause the environment. Distribution of safe waste bags to them and some education will ensure they put cleared dung of their livestock in such bags to minimize methane emission that result from stark disposal. For modern landfills, safety systems as liners, covers, gas and liquid extraction should be integrated. Monitoring wells some distance away will detect contamination. States government may upgrade existing ones before new ones are built. The federal government can also plan for six modern landfills in each of the six geo-political (or compass cardinal point) zone in Nigeria.

Role of International Organizations on Climate Change in Nigeria

The United Nations in a move to commit nations to fight climate change suggests a deal to be ratified by nations; MRV (measurement, reporting and verification) deal or agreement to have nations check and restrain emissions growth over a period. This agreement is a priority for the UN as the next climate change summit nears [18]. For Nigeria, adoption of policies like pollution tax and cancellation of major projects because of emission outlook may not be possible anytime soon, other workable checks that may come in 3-8 years are stated in this draft and other reports alike. Preparing an outlook to submit at the UN summit will also guide moves for Nigeria's climate change response from now. Parts of this draft highlight possibilities from now to around 2018. These are no silver bullets but with the condition of concerted effort and unstained commitment progress in this direction will come for Nigeria. For Nigeria more options for mitigation should come to table no matter the fractional decrease it is expected to produce. This is necessary because more options are considered for global emission reduction even from the upper atmosphere. The IPCC is considering wider options called 'negative-emission' approach for global warming solution to be submitted in their report of 2013 and 2014. UK scientists in a novel geo-engineering experiment are also approaching global warming from the upper atmosphere in a project with construction underway. Stratospheric Particle Injection for Climate Experiment (SPICE) is expected to reduce atmospheric temperatures caused by global warming [18]. These experiments and other options should help from devastation that may accompany increasing emissions. Nigeria however, from workable plans for mitigation and immediate moves for adaptation will help her survive 'undisturbed' in this era of revelatory climate change.

Conclusion and Recommendations

The foregoing has highlighted the critical challenges faced by the Nigerian agriculture in trying to adapt to the problem of climate change. Both government and the private sector, which should drive the agricultural sector through consistent policies, robust funding and infrastructure development, have failed to accord agricultural adaptation the priority it deserves. Moreover, the anticipated benefit from trade liberalization has failed to trickle down to the African farmer. In addition, the farmers have been slow in changing their farming practices such as bush burning, deforestation, rainfed agriculture and land tenure systems, and they lack the requisite education, information and training necessary to adapt to climate change. These challenges need urgent attention by the relevant authorities because the problems of climate change are already with us. This paper has made recommendations that may guide the actions of these authorities. The government should not only decentralize its programs on poverty/HIV-AIDS and agricultural research (funding and activities), but should make them participatory. In addition, there should be explicit national agricultural policy framework, adequate provision for irrigation, drainage, weather forecasting and other agricultural technological infrastructure, an incentive for training in agriculture, participatory and on-going capacity building for farmers, drought resistant and short duration high yielding crops development, integration of indigenous and modern knowledge on climate change adaptation, strengthening of the extension services, and encouragement of formation of farmer groups. However, farmers cannot shoulder the burden alone. Nigerian government should support farmers by keeping the farming community well informed about climate risk and assisting them adopts farm structures and production methods. The government should continue to provide services for the rural environment especially adapting options to the farming community.

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