Applying the Scientific Method (SM) for Sustainable Development Goals (SDGs) in Benue State, Nigeria

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Abstract: *This research work presents the Scientific Method, SM, (also called the Scientific Process, SP) as a means of achieving Sustainable Development Goals (SDGs). It posits the possibility of the effective and efficient realization of the SDGs, if people would apply the Scientific Method (SM) in addressing all the issues of wealth, health, equality, gender and educational acquisitions stipulated therein. The seventeen Sustainable Development Goals (SDGs) have the eight Millennium Developments Goals (MDGs) of the UNO, which lasted from 2001 to 2015, as their precursors. The SDGs from January 2016 will last till December 2030.This narrative explores the various components of the Scientific Method (SM), including the Science Process Skills and the Scientific Attitudes. Furthermore, it highlights the SDGs and explains, specifically, how the SDGs could be realized using the SM, in Benue State of Nigeria.*

Key Words: *Scientific Method; Sustainable Development Goals (SDGs); Nigeria.*

1. INTRODUCTION:

According to Wikipedia (2017), the scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. To be termed scientific, a method of inquiry has to be commonly based on empirical or measurable evidence subject to specific principles of reasoning. The Oxford Dictionaries Online define the scientific method as 'a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses'. Experiments need to be designed to test hypotheses. The most important part of the scientific method is the experiment.

The Sustainable Development Goals (SDGs) are officially known as Transforming Our World: the 2030 Agenda for Sustainable Development. They are a set of 17 'Global Goals' with 169 targets for attaining them. Spearheaded by the United Nations (UN) through a deliberative process involving its 193 Member States, as well as global civil societies, the goals are contained in paragraph 54 of United Nations Resolution A/RES/70/1 of 25 September 2015.

The Resolution is a broader intergovernmental agreement that acts as the Post 2015 Development Agenda (successor to the Millennium Development Goals (MDGs)). The SDGs build on the Principles agreed upon under Resolution A/RES/66/288, popularly known as The Future We Want. The SDGs were, in large measure, informed by the often quoted assertion by United Nations former Secretary-General Ban Ki-moon that 'we don't have plan B because there is no planet B'.

2. THE SCIENTIFIC METHOD – AN ONGOING AND ITERATIVE PROCESS:

The scientific method (also called the scientific process) is a continuous process, which usually begins with making observations about the natural world. Human beings are naturally inquisitive, so they often come up with questions about things they see or hear and often develop ideas (hypotheses) about why things are the way they are. The best hypotheses lead to predictions that can be tested in various ways, including making further observations about nature. In general, the strongest tests of hypotheses come from carefully controlled and replicated experiments that gather empirical data. Depending on how well the tests match the predictions, the original hypotheses may require refinement, alteration, expansion or even rejection. If a particular hypothesis becomes very well supported, a general theory, principle or law may be developed.

Although procedures vary from one field of inquiry to another, identifiable features are frequently shared in common between them. The overall process of the scientific method involves making conjectures (hypotheses), deriving predictions from them as logical consequences, and then carrying out experiments based on those predictions. A hypothesis is a conjecture, based on knowledge obtained while formulating research questions. The hypothesis might be very specific or it might be broad. Scientists then test hypotheses by conducting experiments. Under modern interpretations, a scientific hypothesis must be falsifiable, implying that it is possible to identify a possible outcome of an experiment that conflicts with predictions deduced from the hypothesis; otherwise, the hypothesis cannot be meaningfully tested.

The purpose of an experiment is to determine whether observations conform with or conflict with the predictions derived from a hypothesis. Experiments can take place anywhere from a college lab to a Science-Tech park. There are difficulties in a formulaic statement of method, however.

Though the scientific method is often presented as a fixed sequence of steps, it represents rather a set of general principles. Not all steps necessarily take place in every scientific inquiry (or to the same degree), and are not always in the same order. Some philosophers and scientists, such as Lee Smolin and Paul Feyerabend (in his *Against Method*), have even argued that there is no scientific method. Nola and Sankey remark that 'For some, the whole idea of a theory of scientific method is yester-year's debate'.

The Scientific Method is the main means by which the scientist carries out his work of inquiry (i.e. investigation or research) and problem-solving. It works with the Scientific Process Skills (depicted as the Hand of Science) and the Scientific Attitudes (depicted as the Heart or Spirit of Science).

The Scientific Process Skills (SPS) include observing, questioning, hypothesizing, inferring, measuring, experimenting, investigating, communicating, classifying and predicting. These activities constitute the basics, according to Padilla, (2017). He identifies other activities as the integrated SPS such as controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting and formulating models

A brief description of eight of the basic process skills gives the indication of their significance to sustainable developments. They are as listed below:

Observing: watching and perceiving carefully with the senses of seeing, hearing, smelling, tasting and feeling where applicable; collecting data conscientiously based on observation results, comparing and contrasting the data. Sometimes instruments are used as aids where the functioning of our natural senses is inadequate or impossible.

Research Questions: asking questions about observations that can lead to investigation, inquiry, experimentation, and problem solving.

Hypothesizing: providing explanation that is consistent with available observation from the analysis of data.

Predicting: suggesting an event in the future, based on previous observational data

Investigating (i.e. inquiry): planning, controlling variables, measuring, experimenting, collecting, collating and processing of data.

Interpreting: synthesizing, analyzing, drawing conclusions, seeing patterns and formulating theories, principles and laws based on valid, reliable and reproducible evidence.

Categorizing (i.e. sorting things out): classifying by distributing things into classes of the same type.

Communicating (i.e. reporting): informing others in a variety of means such as oral, written and representational reporting. The skills work effectively and efficiently with the scientific attitudes, which every scientist is expected to imbibe and develop.

Kozlow and Nay (1976) listed nine Scientific Attitudes as critical- mindedness, suspended judgment (or restraint), respect for evidence, honesty, objectivity and willingness to change opinions. Others were open-mindedness, questioning attitude (or inquisitiveness or curiosity) and tolerance of uncertainty.

Gerlovich and McElroy (2009) enumerated twenty Scientific Attitudes. They include empiricism, determinism, belief (e.g. that every problem has a solution), parsimony, scientific manipulation, skepticism, precision, willingness to change opinion, respect for paradigms and respect for power of theoretical structure. Other attitudes listed are loyalty to reality, aversion to superstition and an automatic preference for scientific explanation, a thirst for knowledge (i.e. an intellectual drive), suspended judgment, awareness of assumptions, readiness to separate fundamental concepts from irrelevant or unimportant ones, respect for quantification and appreciation of mathematics as a language of science, an appreciation of probability and statistics, an understanding that all knowledge has tolerance limits and empathy for the human condition. In recent times, team-spirit, collaboration, aptitude for the use of instrumentation and technology, have been added to the list.

Benue State is in the Middle Belt, which is in the north central political zone, of Nigeria. It has a population of more than four million people, according to the 2006 national census. It is designated as the Food Basket of the Nation of Nigeria. It comprises many ethnic groups most of whom are the Tiv, Idoma, Igede, Jukun, Hausa and others. Their main occupation is agriculture; hence, the government's focus is on the use of science and technology for its socio-economic development. Moreover, the State has a high concentration of science and science-related institutions. It is endowed with a lot of human and material resources (including those derivable from water, mineral and energy sources).

Appendix A indicates the iterative and cyclic nature of the SM while appendix B shows the logos and descriptions of the extinct MDGs and extant SDGs, using figures and tables.

3. THE SUSTAINABLE DEVELOPMENT GOALS (SDGs):

On 19 July 2014, the UN General Assembly's Open Working Group (OWG) on Sustainable Development Goals (SDGs) forwarded a proposal for the SDGs to the Assembly. The proposal contained 17 goals with 169 targets covering a broad range of sustainable development issues. These included ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests.

On 5 December 2014, the UN General Assembly accepted the Secretary-General's Synthesis Report which stated that the agenda for the post-2015 SDG process would be based on the OWG proposals.

The Intergovernmental Negotiations (IGN) on the Post 2015 Development Agenda began in January 2015 and ended in August 2015. Following the negotiations, a final document was adopted at the UN Sustainable Development Summit on September 25–27, 2015 in New York, USA. The title of the agenda is *Transforming our world: the 2030 Agenda for Sustainable Development.*

The MDGs were drawn, as an action plan, from the Millennium Declaration of 1999, the Millennium Summit of the United Nations in 2000 and the agreement in the 'Future We Want' outcome document. All these documents served as a precursor of the SDGs.

4. APPLICATION OF THE SCIENTIFIC METHOD FOR THE REALIZATION OF THE SDGS:

According to Jawaharlal Nehru (first Prime Minister of India), in a back page postscript of Nwadinigwe (2004), 'It is science alone that can solve the problems of hunger, poverty, insanitation and illiteracy, superstition and deadening customs and traditions, of vast resources running waste, of a rich country inhabited by starving people…' Although, not exhaustive, appendix A tabulates a detailed list of the Scientific Method's aims, process skills and attitudes. Science believes that all problems have solutions which can be solved either through discoveries or inventions. Hence, without deterrence, it delves into experimentations and inquiry to find a solution to any problem or challenge confronting humanity. The SDGs are expressions of the problems confronting human-kind, hence it is only the problem-solving abilities and aptitudes of the scientific method (SM) that can be used to find solutions to them.

Consequently, the advanced nations of the world have adopted many scientific strategies through SM to sustain their development. For instance, the National Science Foundation (NSF) of the United States of America (USA) is an institution which regularly employs the SM to proffer solutions to problems and challenges confronting the United States, in particular, and the entire world in general. All the developed and developing nations have their respective bodies for scientific and technological development through research or inquiry that is dependent on SM. Similarly Benue State, Nigeria, which has an agro-based economy, can attain the SDGs by using the SM.

5. CONCLUSION:

The SM's nature of inquiry, investigation, experiment, discovery and inventions enables scientists to find solutions to problems confronting humanity. The earth is endowed with vast and sustainable human, material and energy resources. These resources can be harnessed and transformed, by humanity (without discrimination on the basis of gender, religion or ethnicity), into wealth, health and general well-being of all human beings and their environment by the SM. If the advanced and the developing nations of the world are using SM for socio-economic development, Benue State and, indeed, Nigeria cannot be an exception. They need the SM for the realization of the SDGs before the year 2030.

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APPENDIX A

Fig.1: Iterative and cyclic nature of the Scientific Method

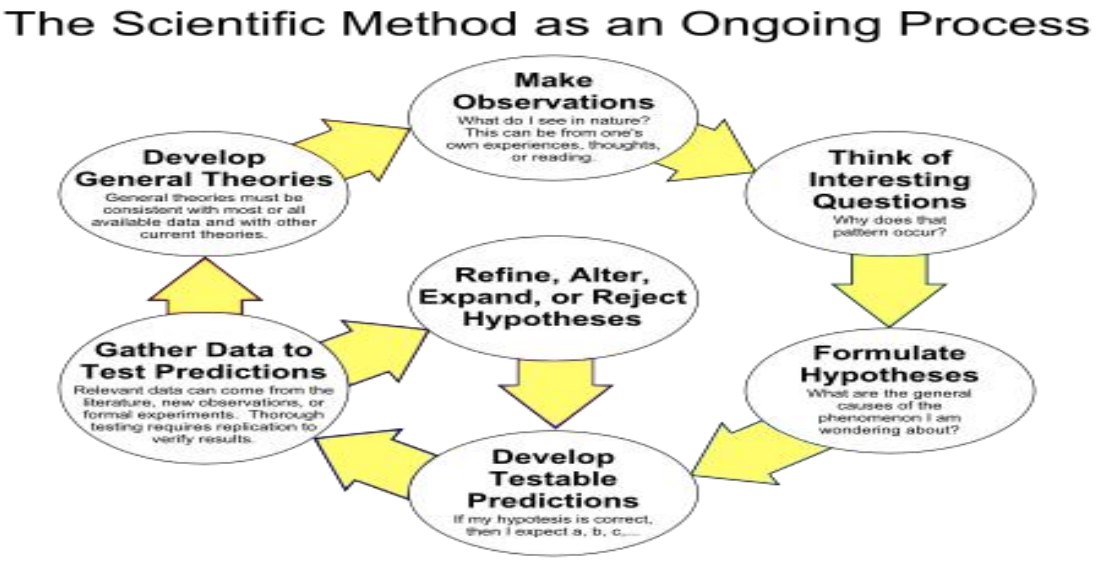


Table 1: The Scientific Method – Its Nature and Some of Its Skills and Attitudes

Nature of the SM	Science Process Skills	Scientific Attitudes
1. Inquiry	Identifying and delimiting problems	Curiosity, objectivity, humility, honesty, realism,
2. Experiment	Observing with the senses and with aid of instruments	perseverance, team-spirit, open-mindedness,
3. Investigation	Using research questions and hypotheses	diligence, intellectual drive, orderliness,
4. Problem-solving	Experimenting by taking measurements and records	apt to use instruments, critical-mindedness,
5. Discovery	Collecting, collating and analyzing data with the aid of mathematics/ statistics	suspended judgment, respect for evidence and authority, **skepticism**
6. Invention, innovation, improvisation and creativity	Classifying to sort things according to their types	willingness to change opinions, tolerance of uncertainty, **empiricism,**
7. Technology	Interpreting data to make inferences, predictions and form theories and laws	**determinism, parsimony, belief in problem-solving,**
8. Engineering	Drawing logical conclusions and honestly reporting findings	**precision, empathy for humanity, mathematical orientation, logic, etc,**

APPENDIX B

Figures and tables showing the logos and descriptions of the MDGs and SDGs

Fig. 2: Logos of the MDGs and SDGs

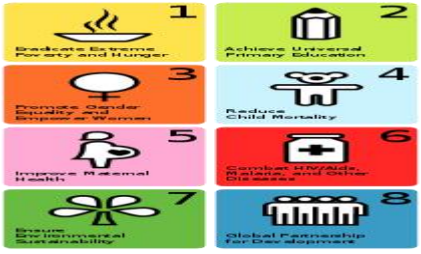
Logos of the MDGs	Logos of the SDGs
	

Table 2: List of the extinct MDGs

The Extinct MDGs		
1. Eradicate extreme poverty and hunger	4. Reduce child mortality	7. Ensure environmental sustainability
2. Achieve universal primary education	5. Improve maternal health	8. Develop global partnership for development
3. Promote gender equality and empower women	6. Combat HIV/AIDS, malaria and other diseases	

Table 3: List of the mottos and descriptions of the extant SDGs:

Extant SDGs: Motto of Each SDG	Description of Each SDG
1. No poverty	End poverty in all its forms everywhere
2. Zero hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
3. Good health and well-being	Ensure healthy lives and promote wellbeing for all at all ages
4. Quality education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Gender equality	Achieve gender equality and empower all women and girls
6. Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all
7. Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
8. Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all
9. Industry, innovation and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
10. Reduced inequalities	Reduce inequality within and among countries
11. Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12. Responsible consumption and production	Ensure sustainable consumption and production patterns
13. Climate action	Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
14. Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and halt biodiversity loss
16. Peace, justice and strong institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Partnerships for the goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development