Ghana Ecological Risks: A Space Law and Science Education Approach to the Management Frameworks

EMMANUEL NARTEY (✉ maninartey@gmail.com)
The Open University

Research Article

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Abstract

This article discusses what Ghana needs to do to progress its space programme to aid the development of legal and scientific education programmes for the management framework of biodiversity and the ecosystem. The first part of the article examines previous academic literature produced on this topic, which offers many clues about the challenges and opportunities facing Ghana, as well as the lessons that can be learned from both other space nations and actors in this field. When looking at perceptions, the second part explores material taken from ethically approved interviews which were conducted with experts in this field, whilst the third section provides an analysis of data taken from a survey in which respondents were asked targeted questions about Ghana's space and science education programmes, before summarising the key findings. The findings help to better understand the effect of biodiversity and the ecosystem. Finally, it is recommended that future work is required in the areas of: preserving, sustaining and maintaining biodiversity and the ecosystem; management frameworks for invasive species and biosecurity; management frameworks for environmental degradation and climate change; a management framework that focuses on the fair and equitable access to and sharing of the benefits of biodiversity resources with all communities in Ghana; and assessing and including biodiversity and ecosystem in the development process of space law and science education.

Introduction

In 2007 Ghana discovered oil and gas and it commenced production in the last quarter of 2010. Whether the discovery of oil and gas exculpates the natural resource curse that has existed with these economic activities requires a further investigation. The first objective debate on this question should centre on whether Ghana's oil and gas discovery promotes economic development or hinders it (Yalley and Ofori-Darko, 2012). The second is whether space law and science education can promote sustainable development in the country (Oyedepo, 2012). Furthermore, natural resources create a dogmatism curse. This dogmatic curse can be illustrated by the fact that excessive resources have an adverse impact on economic development. This was found in Sachs and Warner's (1995; 2001) analysis of the relationship between natural resources and economic growth (Cotet and Tsui 2013). Additionally, the literature on the "natural resource curse" recognises the different factors that affect the relationship between an excessive natural resource and economic growth. Angrist and Kugler (2008) and Aragón, Chuhan-Pole and Land (2015) have suggested these influencing factors are conflict, weak governance structures and weak democratic systems. When a demystification practice is in place in examining nature resources, it is adequate to observe that the argument of the natural resource curse is only valid when the compound element of governance is diminished. This compound element is made up of regulation, education and economic activities. These elements must be adequately balanced to circumvent the path of a natural resource curse. Therefore, while a natural resource is a gift (Gunton et al, 2021) how that gift is managed needs to be examined. If this question can be attributed to the current deficiency in Ghana's oil and gas exploration, the significance of this issue has received little attention in the past decade.

Even though the discovery of oil and gas in Ghana was welcomed by many Ghanaians, the ecological impact and its stratification on individual lives were not apprehended by the average person in the country. Despite the economic benefits promised by the government, there is a lack of scientific data to explain the long-term ecological impact of oil and gas production on the country (Sakyi et al, 2012). This failure can be attributed to the first and second parts of the compound element of governance in the context of a natural resource curse: regulation and education. Therefore, whether these deficiencies can be resolved through regulation and education is definitively something that requires further attention. Of course, it is possible to assume that the excitement brought about by the oil and gas exploration may have overlooked the consequences and detrimental effects on the ecosystem. However, the lack of an inclusive legal and scientific approach to the management framework of the ecosystem forms the compound basis of the destruction of 'traditional smallholder livelihoods' (Viada et al, 2010, April). The compound element effect is the failure of regulation and the science education system to measure and examine the impact of industrial activities on the greater good. Therefore, the greater good becomes an element that should form the basis of our understanding of the management framework. Understanding the management framework of the ecosystems means correlating space law and science education to the mainstream of our decision making. Given the methodology and practical approach to the issue, this means the social and economic aspects of Ghana's oil and gas exploration must be examined through the lens of space law and science education.

From previous research in this field, it is also clear that Ghana is not the only country in Africa to have suffered from this natural resource dogmatic curse and delusional effect. For example, countries such as Nigeria, Congo, and Mozambique are also suffering from the natural resource dogmatic curse and delusional effect (Numbere, 2018). The delusional effect simply means implementing an economic policy that undermines the ecosystem and the societal good. Therefore, the destruction of the livelihood of the local people and environmental degradation are the consequences of oil and gas exploitation in Africa (including mining, legal and illegal). This is further complicated by the deficiency in regulations and science education in the country. Hence, you cannot separate the gap in regulation and science education from the management framework of the ecosystems. Inclusively, in order to manage the ecosystem, there must first be a better regulatory system, and second, there must be a better education system. Taken together, these two distinctive approaches will help strike a balance between better economic requirements and society's demands. Therefore in our understanding of natural resource dogmatic curse and delusional effect, whichever method we choose should have a comparative knowledge of space law and science education, which are the origin of all governance and management frameworks. In this article, I shall endeavour to explain the path to a better understanding of space law and science education and to paint a picture of where space law and science education can intersect to resolve the compound issues of this natural resource dogmatic curse and delusional effect.

The resolution to combat the negative results of natural resources is first to develop an effective scientific resource to examine the side effects of the activity and second to create an effective legal mechanism that is capable of regulating the operations of this activity. So, if one is to see the full benefit of natural resources then the ecosystem must be protected by legal and scientific principles. These principles can

only come about when there is investment in the development of legal and science education in the country. Therefore, the issue of the management of the ecosystem is a development approach, not an experimental approach. This means moving from economic maximisation to conceptualising ideas that require closer attention to the development concepts of an ecosystem management framework in space law and science education in the hope of better understanding the correlation between risk and the modern explanation of the natural resource dogmatic curse and delusional effect.

Take, for example, the environmental destruction and the deterioration of the livelihood of Ghanaians could have been prevented if adequate science education, data, and legal regulation were present from the beginning of the oil and gas exploitation, including mining. Due to this, the destruction of the ecosystem took a different pathway, both in its simple and complex forms (Aryeh-Adjei et al, 2015). This pathway consists of a lack of assessment and monitoring systems in the extractive industry. Therefore, it is now important that multiple theoretical and practical approach is adopted to better understand the complex connection between the negative consequence of natural resource exploitation in Ghana. The potential source of environmental pollution in oil and gas production and their impact on the ecosystem has been overlooked by the authorities. However, this is not only the deficiency that exists in 'Ghana's quest for oil and gas', and the existing domestic law for the environment in the extractive sector, and the compliance, enforcement, and prosecution mechanism is a defined shadow (Alemzero, et al, 2021).

This means that the country in its capacity lacks the structural formation to gather scientific data, process data, and pass laws that are adequate to protect the ecosystem and preserve it for future generations. This lack of science and regulatory approach may have created a gap in attitude, knowledge, development, and the enforcement of adequate legislation to protect the ecosystem in Ghana. The lack of capacity is a disposition, which is also created by the compound element of failed law and failed scientific education. Therefore the problem with Ghana's ecosystem lies in the fragmentation and incoherent policies that are filtered in the attitude toward environment law and science education. While it is not advisable for one to burden society with scientific and legal dogma, it is equally important for science education to inform policy and transform the livelihoods of Ghanaians. In relation to the points I have made thus far, when we observe the destruction of Ghana's ecosystem, there is a clear correlation between the behaviour of ordinary Ghanaians and the classical impact of oil and gas on their livelihoods. However, complexities exist in the development and historical understanding of what management of the ecosystem means in terms of oil and gas exploration. Therefore, trying to bridge this complication in the historical development of oil and gas exploration might help build a good connection between economic activities in Ghana and the management of the ecosystem.

Let us not forget that Ghana's oil and gas exploration started as early as 1896, while the current economic adventure started in the year 2007 (Acquah-Andoh, et al, 2018). Thus, the economic impact of oil and gas production in Ghana cannot be disputed; however, the lack of scientific data and regulation has no doubt contributed to the crimping of the Ghanaian ecosystem. Instead of the generation of revenue and jobs, to improve the country, there is destruction of the environment and deprivation of the healthy state of the natural order (Amoasah, 2010). When examining the distortion of the natural order in line with the current

structural formations in the country, it is evident that there are some existing environmental laws in Ghana that are aimed at regulating mining and oil operations (Mahama, 2016). The paralysed scientific data and regulation (in other words, inadequate laws) have left the oil and mining sector unregulated for many decades. This legal and scientific deficit has led to the destruction of the livelihood of Ghanaians, damaged biodiversity, and destroyed the basic structure formation that the average Ghanaian depends on to live. This means that policymakers need to pay close attention to the ecosystem and sustainability strategies that will ensure that oil, gas, and mining exploitation does not have an adverse effect on the ecosystem. Fundamentally, this approach is a dependency formation, which requires the interrelation and the interplay of science policy to resolve the environmental issues confronting the Ghanaian people.

Therefore, for the policymakers to comprehend the facilities that are required to resolve the issues surrounding the ecosystem and sustainability, there is a need for a better understanding of the correlation between law and science resolution. Without this basic understanding, the policymakers are incapable of developing appropriate tools that are centralised on solving the problem. Take, for example, the fact that there are over 90 lagoons along the whole coastline of Ghana, the majority of which are located in the central and western coastlines, including the Cape Three Points area. Fish, shrimp, mollusc, and crab species are the habitat of these sites (Armah, et al, 2011). The ecology of the Cape Three Point area is widely split in two: offshore and onshore. The offshore ecosystem has around 89 species, which are aquatic organisms. These organisms are found in the 1,100–1,700 m water depth in the Jubilee Field. The onshore ecology is sandy shores that surround the Cape Three Point region. This point is used by sea turtles for nesting and other species such as ghost crabs, isopods, amphipods, mysids, and mole crabs inhabit this place. Furthermore, the sandy shore is a living place for creepers, grasses, dwarf palms, coconut palms, and shrubs. When close attention is paid to the offshore and onshore inhabitants, the urgency of the matter becomes one of an open-end loop. We can therefore say that there is a need for space science to oversee the progressive development of the sites and law is required to regulate the conduct of the actors engaged in these sites (Klinger, 2020). This approach should be at the heart of the management framework of the ecosystems in Ghana.

On this basis, this article will discuss what Ghana needs to do in order to progress its space law and science education programmes to aid the development of legal and scientific education programmes for the management framework of the ecosystem, for which there is clearly much potential at present. The first part of this discussion will examine previous academic literature produced on this topic, which offers many clues about the challenges and opportunities facing Ghana, as well as the lessons that can be learned from both other space nations and actors in this field. When looking at perceptions, the second part will explore material taken from ethically approved interviews which were conducted with experts in this field, whilst the third section will provide an analysis of data taken from a survey in which respondents were asked targeted questions about Ghana’s space and science education programme, before summarising the key findings.

Methodology

The primary research method for this project is a literature review of space law and Education in Ghana and an online structured questionnaire survey (created using the JISC Online survey tool) is used to gather information on knowledge of, and attitudes towards, space law, policy, technology and science education in Ghana. A semi-structured interview with 5 stakeholders such as teachers, researchers and members of relevant organisations, such as the Ghana Space Sciences Institute. The interviews are conducted by a contracted researcher and took place online (via Teams) and audio-recorded.

For the online survey, a snowball sampling method is used to approach school teachers, university academics and PhD students, policymakers and space sector employees in Ghana.

For the interviews, a convenience sample of 5 stakeholders (teachers, university academics and members of relevant organisations in Ghana, such as the Ghana Space Sciences Institute) was identified from existing networks and connections; direct invitation by email from the PI.

Space Law Policy And Education Survey Response

Along with interviews, both Dr Sarah Davies and Dr Emmanuel Nartey conducted a survey about Space Law, Policy and Education in Ghana. Twenty-four persons participated and overall, there was a 48 per cent response rate. 91 per cent of the participants were aged between 25 and 54, of which only 4.2 per cent each were from the 18-24- and 55-64-years age bracket. 45.8 per cent of the participants were male and 54.2 per cent were female. In terms of occupational composition, 29.2 per cent came from the education sector including schools, colleges and universities; 8.3 per cent were policymakers; 4.2 per cent came from the legal profession and 58.3 per cent declared ‘Other’, for which the range of occupations included people from business, marketing, human resources, science and engineering. With regard to disciplinary background, 45.8 per cent were involved with STEM; 8.3 per cent came from Law; 12.5 per cent were involved with Economics; 16.7 per cent from Development Studies, whilst 29.2 per cent stated that they were involved in Geography, Psychology, Hospitality or Sport.

Jisc Online surveys

Space Law Policy and Education

Showing 24 of 24 responses

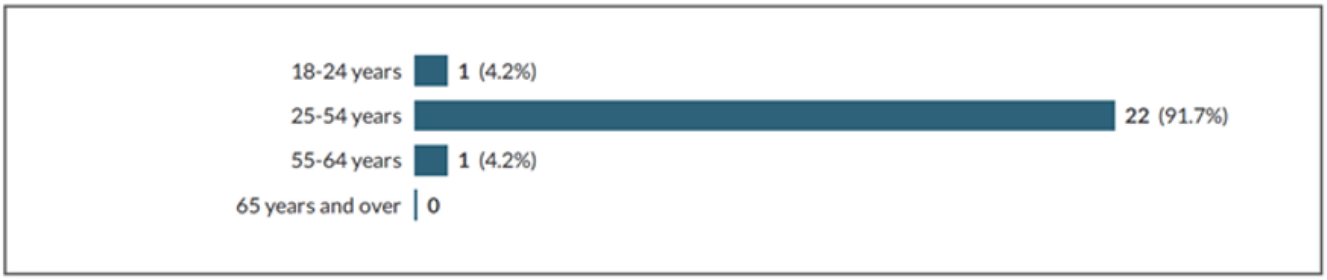
With **1 response excluded**

Showing **all** questions

Response rate: 48%

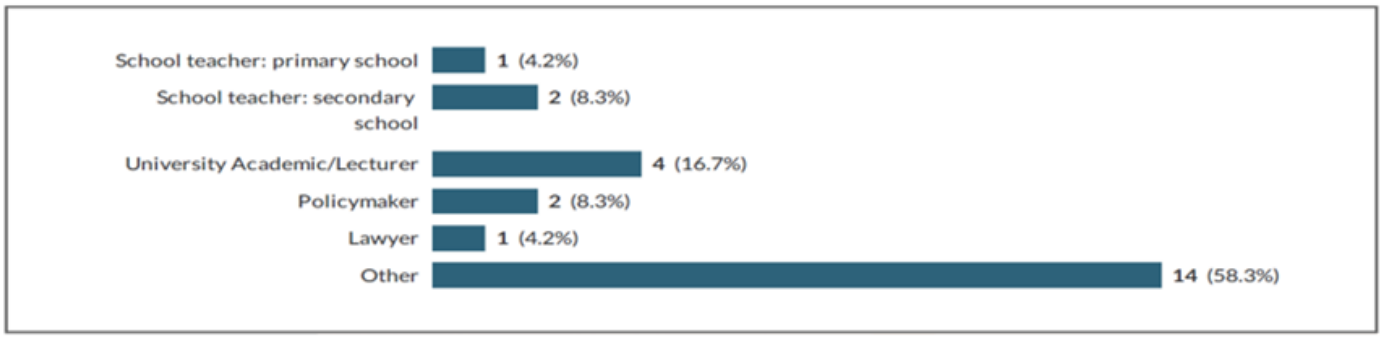
1 By ticking 'Yes' below, I agree to take part in this study.

2 1. What is your age?

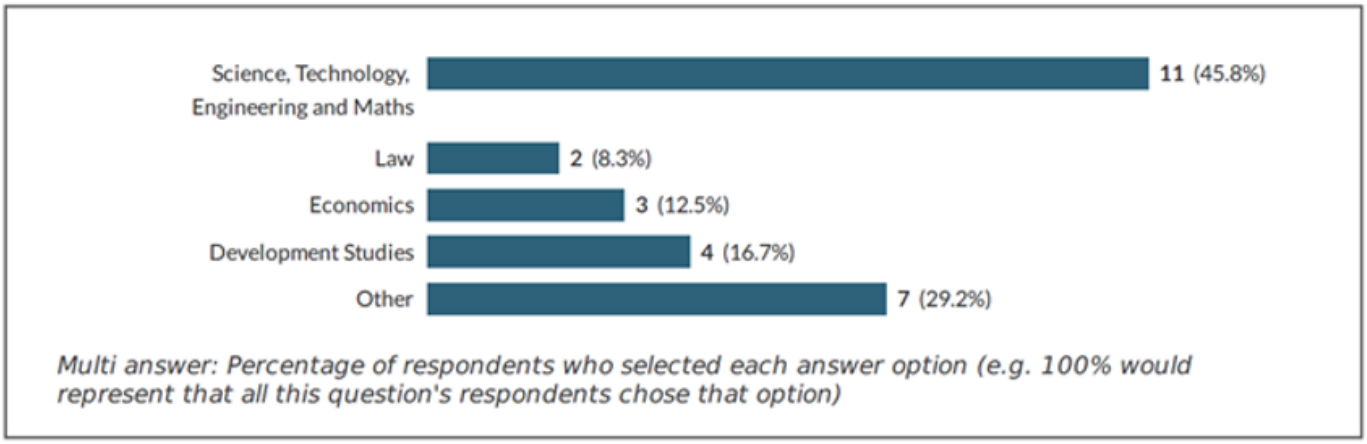


3 2. What is your sex?

4 3. What is your profession?



5 4. What is your discipline background? Please select all that apply



Discussion

The first question posed to the respondents was, 'Are you aware of the Ghana Ministry of Environment, Science, Technology and Innovation's policy to support education for space research and innovation?' In response, 16.7 per cent were aware of this, whilst 83.3 per cent said that they were not aware, all of which ties in with an argument made by one of the interview participants that there is a dichotomy and chasm within Ghanaian society and public life about the importance of space science in aiding development.

With regard to the next key question, 'Do you think that promoting space science education should be a priority?' 82.6 per cent agreed that it should be, whilst 17.4 per cent disagreed. For those who said 'Yes', the respondents were asked which topics should be a priority. The responses were quite varied in a sense that environmental management and topics such as water monitoring, agriculture, natural conservation and the use of satellite technology for environmental surveillance featured prominently, along with the need to tackle climate change. There was also an acknowledgement amongst participants that given space science is an emerging field, more investment in human resources and capital, along with education were listed, whilst some responses felt that more options for young people, raised standards of living, greater infrastructure investment and better healthcare provisions should be prioritised instead.

When asked 'What space science education activities are you aware of in Ghana?' the majority of respondents had no awareness that any activities were in motion. For those respondents who declared

awareness, the SKA project was mentioned; as were Ghana's links to South Africa's space activities, along with outreach events and satellite telecommunications. A couple of participants were aware of the work being undertaken by the Ghana Space Science and Technology Institute (GSSTI) and initiatives conducted by the space observatory.

The ninth question in the survey asked participants 'What is your understanding of Ghana's current involvement in space?' Many of the respondents answered that they had either little or no knowledge at all. For those who responded that they possessed knowledge, there was knowledge about the launch of Ghana's first satellite and the work of the GSSTI was mentioned, as well as the observatory. One of the respondents complained about the institution being 'seriously understaffed' and not funded to carry out its mandate, whilst another knew about space projects that were being conducted at a grassroots level, but was completely unaware that a 'comprehensive space programme' existed.

When participants were asked, 'How do you feel about Ghana's current involvement in space?' some of the responses were fairly mixed. One respondent acknowledged that whilst Ghana was ahead of other African states in terms of the development of its space and science education initiatives, on a global scale, it was behind many other countries. On the same topic, another respondent felt discouraged by the 'current achievements' of sister nations, whilst other sceptical responses noted that Ghana was 'scratching the surface' and were not impressed with current efforts. For those participants who were supportive of Ghana's involvement in space, there was a perception that this is not only good for the younger generations of Ghanaians, but they felt that more money should be committed to space science, along with the need for the Ghanaian government to become more proactive on the international stage, in terms of technological development and international space laws and decision-making.

Another question posed to participants interacting with the survey was 'What are your hopes and aspirations for Ghana's future involvement in space?' The majority of respondents reacted positively to this question, with a couple saying that Ghana's geographical location meant that the country had much to offer, especially in terms of training opportunities. Located close to the equator and sea-faring, the potential of Ghana as a region for the safe launching of rockets into space was highlighted. Some respondents also saw the potential for Ghana to develop its own ecosystem, as well as retain its own personnel.

When asked if 'The United Nations Office for Outer Space Affairs and African Union are both keen on using space assets to achieve the Sustainable Development Goals (SDGs) and whether participants had either encountered or engaged with this?', 81.8 per cent said 'No', whilst 18.2 per cent said 'Yes'. For those who said 'Yes', when asked how they saw space assets being used to achieve SDGs, the responses varied. One respondent suggested that the skills, knowledge and technology needed for space affairs ranges 'across all aspects of the environment'. Another suggested that the application of space data in the area of agriculture could help 'alleviate poverty and provide food for all'.

The final question of the survey asked participants 'How do you think space law and policy affect or impact on general science education in Ghana?' This drew some quite interesting responses. As a whole,

there is positivity about Ghana's space initiatives. There was a feeling amongst most respondents that the introduction of a legal framework and regulation of Ghana's space activities would not only appeal to citizens and educators, but also create an 'enabling environment' for scientific innovation and development, as well as create a culture of aspiration amongst citizens. For those respondents who were quite sceptical, concerns were raised about space laws and how they could infringe upon civil and human rights. Also, whilst there was a perception that satellites could improve communications across Ghana, other policy issues such as health and the environment should be put first.

5. Interview Data on Perceptions of Space and Science Education

When discussing perceptions of space and science education initiatives, as well as confronting the challenges and opportunities facing Ghana in her efforts to become a space-faring nation, during May 2021, Dr Sarah Davies and Dr Emmanuel Nartey from the Open University's Environmental Science and Law Schools organised a workshop and Round Table discussion which brought together academics, scientists, policy makers and legal professionals, all of whom have a vested interest in this topic. Based upon previous research, a range of issues was discussed, from which semi-structured interviews were later conducted with some of the participants. Five key questions about space law, policy, technology and science education were posed, all of which were ethically approved. The rationale behind these questions was to assess whether space science and education could be a valuable tool to resolve the issues of biodiversity and ecosystem in Ghana.

Discussion

The first question asked to participants was 'What is your understanding of Ghana's current involvement in space?' Responses to this question were quite interesting in that they presented a mixed perception of Ghana's space activities. Participant A stated that their understanding was that the majority of work in space activity was being 'undertaken by universities and to a lesser extent, small-scale start-up companies'. This respondent was unaware that other than the Ghana Space Science and Technology Institute, there was no government-funded space research or activity in motion.

Participant B's response to this question stated that public awareness of Ghana's space programme was 'very low', but at a higher level of Ghanaian society, there was a far greater understanding amongst a number of people about the importance of space science. However, as to whether Ghana should invest more resources into space activity, Participant B cautioned that Ghana was still 'battling poverty' and economic issues. From a space science perspective, the respondent asserted that it has been 'a bit of a struggle for politicians' when trying to explain to the wider general public that through space, Ghana can tackle poverty and economic hardship.

There was an acknowledgement that the Ghana Space Science and Technology Institute had created a 'greater awareness' of the importance of space science, but also a realisation that whilst many government ministries and institutions were making use of satellite data, this was being done in an uncoordinated manner with global private sector firms. This participant stated that similar raw data was

being processed differently for different institutions with variable needs, and therefore, a lack of structure and strategy meant that Ghana was wasting resources which could be deployed more efficiently. For instance, when tackling illegal mining, instead of using earth observation data to track this activity, the Ghanaian authorities are still reliant upon both manual means and militaristic means.

On that theme, Participant C's response to this question further noted environmental considerations for the use of space products to address various aspects of the country's development such as monitoring for agricultural purposes, better communications, and transport. This respondent also highlighted that Ghana has broader ambitions to advance from being a 'consumer' of space products towards becoming 'a rare contributor' of space science technology, as well as building innovative products.

The second question posed was 'From your perspective, what are the reasons for Ghana being involved in space science and technology?' Again, the responses were quite varied. Participant A stated that a reason for Ghana or 'any country' wanting to be involved in this field was that as a developing nation, it would provide 'greater impetus' for socio-economic development, as well as many advantages for Ghana. This view was shared by Participant B, who provided a more thorough response by asserting that South Africa's involvement in space science was a key influence in Ghana wanting to participate in this field too. The interviewee added that Ghana's space programme had developed from a variety of small projects and outreach activities involving collaboration with the Square Kilometre Array (SKA) project, which is an international effort to build the world's largest radio telescope, into bigger and more expansive initiatives based upon remote sensing, the establishment of a climate centre, astronomy, and the development of a satellite engineering centre. When selling the space programme to the Ghanaian public, Participant B stated that:

'people are yet to come to terms with using space science for social and economic activities, especially in terms of agriculture, land management and natural resource management which are different aspects of our economic development'.

This respondent also raised issues surrounding a lack of government investment in space science, as well as joined-up public and private sector partnerships, with short-term political considerations and winning elections a greater focus for Ghana's main political parties and actors instead of economic development. This respondent noted that whilst there was an acknowledgment amongst political actors about the importance of space science for the development of Ghana, at the same time, progress was being hindered by a lack of patience and investment.

Participant C's response to this question highlighted the economic advantages and environmental benefits which Ghana can gain from being involved in space science, particularly when tackling illegal mining, which at present is destroying the country's water bodies and causing deforestation, as well as the destruction of farmland. This participant viewed space activities as being a game-changer enabling the environment to be monitored in real-time, for which with the correct earth observation data, every part of the country could be monitored and policies shaped around the data acquired.

The third question which participants had to answer was ‘Have you ever been involved with space science education? Note: space science education topics could include satellite technologies and engineering, satellite telecommunications, global positioning systems (GPS), geographic information systems (GIS), use of satellite data, observation of Earth from space, weather monitoring and forecasting, and environmental surveillance, e.g., for agriculture, mining, nature conservation, and water resources. If yes, would you explain in what way and how useful you think space science education is?’

Responses to this question varied insofar as Participant A had ‘minimal’ involvement in space science, but possessed elementary knowledge of the subject to explain within their field why space law should be more readily considered by Ghana and her institutions and therefore, why law and science should go hand in hand when accessing and using the benefits of outer space. This contrasted with the responses of Participant B and C who both had backgrounds in physics, climatology and earth observation, for which Participant C stressed the need for Ghana and both other countries in Africa and globally to make greater use of available space technology, as well as develop skills and knowledge to achieve ‘systemic and developmental goals’.

In response to the fourth question, ‘Do you think that space science and technology should be included in the general science education in Ghana? What do you think would be the benefits or disadvantages?’, Participant A stated that there would not be many disadvantages except for ‘a limited number of teaching hours’, but also highlighted the many benefits of including space science as a mandatory science education topic, as well as raising greater awareness of the social importance of space science and earth observation data for the monitoring of waterways, the use of natural resources, improving awareness about the dangers of human trafficking, and monitoring food crops – all of which were seen as ‘beneficial’ to being included in the curriculum.

Participant B’s answer to this question revolved around a belief that space science should be taught from a very early stage of schooling with pupils learning the very basics about the solar system to understanding its role in environmental management and monitoring. This respondent felt that the entire curriculum needed to be ‘changed and reviewed’ in order to incorporate space science at every level from early-years education right through to the university sector. One of the reasons given for this stance was the limited skills capacity in earth observation and space science within Higher Education, with only a handful of universities in Ghana specialising in this field, some of which are privately-run. Furthermore, Participant B highlighted that a number of space science activities are already in motion at a tertiary level, and at secondary school level, for which this individual is involved in many outreach activities including summer schools for young astronomers.

The response of Participant C to this question was similar to Participant B, with this respondent claiming that the benefits of space science in education could be ‘enormous’. Participant C mentioned that a current problem in Ghana is the poor utilisation of skills amongst graduates in Higher Education, where a significant number of those graduates employed in occupations such as taxi driving, despite the government investing significant funds in creating Technical Universities and various other education

initiatives. This participant argued that space science should not just be the preserve of the highly-educated, but instead impact and cut across all aspects of Ghanaian society.

In response to the final interview question, 'How do you think space law and/or policy affects science education in Ghana?' amongst all participants, the lack of flexible but strong national laws was a huge concern. Participant A stated that whilst the absence of a legal framework for space activities did not affect science education very much at present, there was an awareness of a draft Bill or policy in motion within the Ghanaian Parliament. The response of Participant B to this question was that space law in Ghana was currently limited to advocacy, for which this was a new area of expertise. This respondent noted that the creation of a legal framework for space activities would not only provide the necessary security to attract private investment and global companies wanting to invest in Ghana, but by following the lead of South Africa, the country should learn from its experience when building the necessary capacity and infrastructure needed to succeed. Participant C possessed similar views and felt that all space activities within Ghana should be regulated to make it 'sustainable, peaceful and beneficial to society', for which the respondent felt that these measures could tackle issues such as space debris, as well as foster cooperation and collaboration across the global community too.

Literature Review

According to the United States (US) Government's Global Hunger and Food Security Initiative in 2017, the increasing population, limited natural resources, development demands, and growing distortion in the climate system are posing both short- and long-term sustainability problems to the Northern Region of Ghana (USAID, 2017). The report indicates the "importance of natural forest, land use, and vegetation for regulating water supply and greenhouse gas emission, enhancing resilience, and providing biodiversity benefit" for Ghanaians. Richard and Marek found that the forests in Ghana face two edge problems, which are deforestation and forest degradation (D&FD) (Kyere-Boateng and Marek, 2021). The outcome of the report seems to suggest that while the population is increasing, there should be an alternative way of examining the use of the ecosystem service. This alternative approach may have underlying factors in the way resources are used, their maintenance, and the regulatory framework required to sustain them in the short- and long-term.

Kyerematen and Obeng-Ofori (2012), noted that the breaking down of traditional Ghanaian belief systems and rapid changes in the socio-economic development have destroyed the Ghana ecosystem service and this poses a threat to its habitants and Ghana. Tindan (2013) observed that even though policymakers have responded to the issue of D&FD in Ghana, the response may have had a direct impact on the environment and vulnerable people in Ghana. However, Gorte and Sheikh (2010) are of the view that government action (or, rather, inaction) is the underlying cause of D&FD in Ghana. They noted that "infrastructural development, law enforcement, land rights/tenure and institutional factors" are the root causes of the problems (Gorte and Sheikh, 2010). Adding to the complication, Mahapatra and Kant seem to suggest that among other things population growth and economic growth may be the direct causes of D&FD.

In their model, they seem to assume that D&FD is caused by six factors: forest, demographic, macroeconomic, agriculture infrastructure, and political (Mahapatra and Kant, 2005). All these studies have highlighted three important aspects of sustainability and preservation of the ecosystems in Ghana. The first part is the management framework, the second is science education and the third is regulation. Without an effective management framework, it becomes comparatively difficult for the country to develop a scientific education system to gather data about the past and make predictions for the future. Thus, without the regulatory aspect of the management framework, all progress becomes redundant and our ability to meet the sustainability goals is weakened. Therefore, the effort to combat D&FD is one that must be grounded in the tripartite approach to the management framework of the ecosystem. The first two – space law and education – have already been discussed, and the third part is the impact of the growing Ghanaian population. All these three depend on each other and they must inform each other in the development of the management framework.

The pressure caused by D&FD has impacted the forest biodiversity and ecosystem service in Ghana. D&FD has also destroyed the wildlife population in Ghana (Emmanuel et al, 2018). As a consequence flora and fauna have been reduced in most parts of Ghana's high forest zone, affecting places such as the Atewa forest reserve, while most water areas are being contaminated and destroyed by illegal surface mining in the forests (Obeng, 2019). This illegal mining is also affecting people living in the rural areas who depend on water from the rivers, streams, and other water bodies for their livelihood. The consequence and implications of these activities are costly, not for only the ecosystems but the healthy state of the country. Nicola et al. (2015) observe illegal and legal cutting down of trees destroys the understory vegetation and its inhabitants such as birds and other mammals.

The changes in forest vegetation from D&FD impact biodiversity and the health of the ecosystem, decreasing the usefulness of the ecosystem (Obeng, et al 2019). The growing impact of D&FD has caused changes in the climate, which has resulted in drought and a rise in temperatures affecting forest biodiversity and the functions of the ecosystems. It is therefore clear that Ghana is facing a significant shift in biodiversity and ecosystem service. Both problems are correlated and its solution is interconnected and interdependent. The shifting face of the system can be attributed to a lack of observation and earth data on the activities in the affected areas. It could also partly be a lack of effective regulatory mechanisms and education to understand the systematic effect of individual or collective activities on biodiversity and the ecosystem functions of the country.

A study by the Food and Agriculture Organization (FAO) in 2010 observed forest management as sustaining the forest in the light of maximum social and economic development without distorting the biodiversity and ecosystems. A point to note in the FAO report acknowledged that the forest resources can be used to produce maximum social and economic benefit without destroying the forest environment. This seems to place no interest in promoting the social and economic benefit of the people dependant on the forest. Thus, it is problematic when one considers the livelihoods of the urban people and the inhabitants of the forest. It also becomes clear from this point that sustainability and management of the forest cannot be achieved without a clear inclusive approach to its development.

Therefore, to achieve better outcomes in the management of biodiversity and the ecosystems, there must be a consultation with the local people, scientists, education professionals, and policymakers. This will ensure appropriate views are incorporated into the preservation of the biodiversity and ecosystems in Ghana.

The question that needs to be asked is whether both the individual and communities' perceptions affect the way biodiversity and the ecosystems are managed in Ghana. If the answer is yes, then there is a need to examine the existing knowledge about biodiversity and ecosystem preservation in Ghana. If the answer is no, then what system can be put in place to preserve the biodiversity and ecosystem of Ghana. According to Tindan, the answer is yes, because the destruction of the biodiversity and ecosystem is due to human activity, which is connected to the way the local people treat the environment. What this seems to suggest is that perhaps the knowledge of the gravity of these activities is not clear to the local people. The reason for this is not clear in Tindan's study. However, even though the Timber Resource Management Regulation LI 1649 was passed, people still cut down the timbers and destroy the environment. There is also an increase in illegal logging and the perpetrators are not held accountable. Whether these issues can be resolved through science education, space observation, and regulation needs to be investigated further if the destruction of Ghana's biodiversity and ecosystem is to be stopped.

The importance of having good space laws in place has been raised by Selman-Ayetey who voiced similar concerns about the absence of not only a flexible space policy but also specific space legislation in Ghana. The country has relevant laws that are interconnected to outer space activities such as the 2008 Electronic Communications Act, as well as policies through being a member of the Economic Community of African States (ECOAS), such as the 2011 Policy on Science Technology and the 2009 National Science, Technology and Innovation Policy, which was revised in 2017. However, whilst from an international perspective, Ghana has signed UN treaties governing space activity, including the 1967 Outer Space Activities Treaty, it has not ratified any of those measures. This means that Ghana is not bound by international laws and therefore, as Selman Ayetey has pointed out, in order to underscore international obligations, domestic laws are needed in Ghana to not only protect her space activities but also provide flexibility and security for any future global investment and cooperation. Could this resolve the issues of biodiversity and ecosystems? This is not clear. However, what is certain is the impact these forms of activity might have on biodiversity and ecosystems

Therefore, if we can conceptualise this, we can say space law and science education could be the desired path for the current situation facing the Ghanaian people. Hence the preservation of the ecosystem and biodiversity becomes the desire of Ghanaians. In this interpretation, we could assume that everyone should be taught and should know what is meant by the preservation of the ecosystem and biodiversity. If this knowledge is attributed to the average person, then we can say everyone knows what there is to do, and thus the preservation of the ecosystem and biodiversity becomes the ultimate defining purpose of the country. For Ghanaians, this knowledge element is important. It is significant in the preservation of the ecosystem and biodiversity for future generations. However, space law and science education require

careful observation. For instance, some people in Ghanaian society may not desire the preservation of the ecosystem and biodiversity. This may include the people who engage in activities such as cutting down timbers and polluting the environment and waterways. These people may not desire what the average person may want or they may not even contemplate their issues, though it may be possible to educate these people about the seriousness of this issue. Educating them on adverse environmental activities may help them gain knowledge and understanding about their conduct and its impact on the ecosystem and biodiversity.

Conclusion

The findings from this research highlight that there are many different factors which affect Ghana's biodiversity and ecosystem. This study has shown that education and a legal infrastructure are needed to support sustainable development in Ghana. The destruction of biodiversity and its ecosystem is a serious problem. Urgent action is needed to map out a strategy to reduce the long-term impact this may have on the environment. Therefore, the management of biodiversity and ecosystems is vital for building Ghana's climate resilience. If these issues are not addressed, human and natural resources will be severely affected in the future. The loss of habitats, land degradation, increasing pollution and a damaged ecosystem will cause irreparable harm, for which an action plan is needed.

Combined draft science education and space laws are needed to manage biodiversity and the ecosystem, with the ability to educate and regulate the conduct of all actors involved. Such tools will not only help bridge the gap between biodiversity and ecosystem management in Ghana, but will also provide observation data and security for the state authorities to deal with illegal mining and environmental degradation in many affected areas across Ghana. Education can help better understand the effects of illegal activities, as well as equip Ghanaians with better knowledge about their environment and how to preserve it for future generations.

Going forwards, this article recommends that future work is required in the areas of: preserving, sustaining and maintaining biodiversity and the ecosystem; management frameworks for invasive species and biosecurity; management frameworks for environmental degradation and climate change; a management framework that focuses on fair and equitable access to and sharing of the benefit of biodiversity resources with all communities in Ghana; and assessing and including biodiversity and ecosystem in the development process of science education and space law. These recommendations are based on the fact that urgent action is needed across all levels of government and society.

Overall, when discussing the many challenges and opportunities facing Ghana in the development of its space and science education programmes, it is highly apparent that despite the success of GhanaSat-1 and other space activities, more funding and joined-up public and private sector investment is required, along with the need to adopt space laws shaped around a legal framework designed to provide security for the country itself and any potential investors. Further, in creating the necessary cohesion for Ghana’s space and science education initiatives to succeed, greater cooperation and coordination amongst actors

both domestically and globally is needed, along with an overarching strategy to support biodiversity and the ecosystem in Ghana.

Declarations

Ethical Approval

All OU research involving the collection of data or biological samples from human participants requires assessment by the Human Research Ethics Committee (HREC) (please refer to the 'What needs HREC review' guidance for confirmation of data collection activities that will not require an ethics review by HREC, including internal service review/evaluation and audit activities).

It is essential that no potential participants are approached until you have received a formal response from HREC.

Survey: Dr Nartey and Dr Davies have set up JISC Online Survey accounts. Dr Davies will download the raw data and de-identify it. The raw data will be held on her Open University-controlled computer in a password-protected document. She will permanently delete the survey responses from the JISC Online Survey tool no later than 31st December 2021. The de-identified responses will be securely stored in password-protected files on computers managed by the Open University. They will only be shared with the contract researcher and members of the project team at the Open University. Anonymised data will be stored until 31st August 2022, then transferred to the OU data repository.

Interviews: The only people who will have access to copies of the audio recordings of the interviews will be the contract researcher, the transcriber and the project team. All copies of the recordings will be securely stored in password-protected files on computers managed by the Open University. Once the transcript has been made, and no later than 31st August 2021, all copies of the recordings will be permanently destroyed.

The de-identified transcripts will be securely stored in a password-protected file on computers managed by the Open University. The transcripts will only be shared with the contract researcher and members of the project team at the Open University.

Signed consent forms will be stored by Dr Nartey in password-protected files on a computer managed by the Open University (separately from the recordings and transcripts) until 31st August 2022, then permanently destroyed.

The project has been registered with FBL and added to the Risk Register – asset number 34

Competing interests

Not applicable

Authors' contributions

Dr Emmanuel K Nartey

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Availability of data and materials

Applicable

References

1. Acheampong, M. (2018). *Assessing the Impacts of Ghana's Oil and Gas Industry on Ecosystem Services and Smallholder Livelihoods* (Doctoral dissertation, University of South Florida).
2. Acquah-Andoh, E., Gyeyir, D. M., Aanye, D. M., & Ifelebuegu, A. (2018). Oil and Gas Production and the Growth of Ghana's Economy: An Initial Assessment. *International Journal of Economics and Financial Research*, *4*(10), 303-312.
3. Alemzero, D. A., Iqbal, N., Iqbal, S., Mohsin, M., Chukwuma, N. J., & Shah, B. A. (2021). Assessing the Perceived impact of Exploration and Production of Hydrocarbons on Households Perspective of Environmental Regulation in Ghana. *Environmental Science and Pollution Research*, *28*(5), 5359-5371.
4. Alexeev, M., & Conrad, R. (2009). The Elusive Curse of Oil. *The review of Economics and Statistics*, *91*(3), 586-598
5. Amoasah, G. (2010). The Potential Impacts of Oil and Gas Exploration and Production on the Coastal Zone of Ghana: An Ecosystem Services Approach. *Unpublished master's thesis, Wageningen University, Wageningenur*.
6. Angrist, J. D., & Kugler, A. D. (2008). Rural Windfall or a New Resource Curse? Coca, Income, and Civil Conflict in Colombia. *The Review of Economics and Statistics*, *90*(2), 191-215.
7. Aragón, F. M., Chuhan-Pole, P., & Land, B. C. (2015). The local economic impacts of resource abundance: What have we learned?. *World Bank Policy Research Working Paper*, (7263).
8. Arcilla, N., Holbech, L. H., & O'Donnell, S. (2015). Severe Declines of Understory Birds Follow Illegal Logging in Upper Guinea Forests of Ghana, West Africa. *Biological Conservation*, *188*, 41-49.
9. Armah, F. A., Odoi, J. O., Yengoh, G. T., Obiri, S., Yawson, D. O., & Afrifa, E. K. (2011). Food Security and Climate Change in Drought-Sensitive Savanna Zones of Ghana. *Mitigation and Adaptation Strategies for Global change*, *16*(3), 291-306.
10. Aryeh-Adjei, A. A., Abdul-Fatahi, A., & Mohammed, F. (2015). Interim Environmental Influence of Oil Exploration on Human Lives in Ghana: a Case of Half Assini and Efaso. *International Journal of Water Resources and Environmental Engineering*, *7*(8), 101-108.
11. Balzan, M. V., Pinheiro, A. M., Mascarenhas, A., Morán-Ordóñez, A., Ruiz-Frau, A., Carvalho-Santos, C., & Geijzendorffer, I. R. (2019). Improving Ecosystem Assessments in Mediterranean Social-Ecological

Systems: a DPSIR Analysis. *Ecosystems and People*, *15*(1), 136-155.

12. Cotet, A. M., & Tsui, K. K. (2013). Oil and conflict: What does the cross country evidence really show?. *American economic journal: Macroeconomics*, *5*(1), 49-80.
13. Dwomoh, F. K., Wimberly, M. C., Cochrane, M. A., & Numata, I. (2019). Forest Degradation Promotes Fire During Drought in Moist Tropical Forests of Ghana. *Forest Ecology and Management*, *440*, 158-168.
14. Emmanuel, A. Y., Jerry, C. S., & Dzigbodi, D. A. (2018). Review of Environmental and Health Impacts of Mining in Ghana. *Journal of Health and Pollution*, *8*(17), 43-52.
15. Gorte, R. W., & Sheikh, P. A. (2010). Deforestation and Climate Change.
16. Gunton, T., Werker, E., & Markey, S. (2021). Community benefit agreements and natural resource development: Achieving better outcomes. *Resources Policy*, *73*, 102155.
17. Klinger, J. (2020). China, Africa, and the Rest: Recent Trends in Space Science, Technology, and Satellite Development.
18. Kyere-Boateng, R., & Marek, M. V. (2021). Analysis of the Social-Ecological Causes of Deforestation and Forest Degradation in Ghana: Application of the Dpsir Framework. *Forests*, *12*(4), 409.
19. Mahama, A. I. (2016). *An Assessment of Activities of Multinational Oil Companies and their Effects on the Marine Fisheries Industry in Ghana since 2007* (Doctoral dissertation, University Of Ghana).
20. Mahapatra, K., & Kant, S. (2005). Tropical Deforestation: a Multinomial Logistic Model and Some Country-Specific Policy Prescriptions. *Forest Policy and Economics*, *7*(1), 1-24.
21. Nganso, T. B., Kyerematen, R., & Obeng-Ofori, D. (2012). Review of Biodiversity in Sacred Groves in Ghana and Implications on Conservation. *Current Trends in Ecology*, *3*, 1-10.
22. Numbere, A. O. (2018). The impact of oil and gas exploration: invasive nypa palm species and urbanization on mangroves in the Niger River Delta, Nigeria. In *Threats to mangrove forests* (pp. 247-266). Springer, Cham.
23. Obeng, E. A., Oduro, K. A., Obiri, B. D., Abukari, H., Guuroh, R. T., Djagbletey, G. D., ... & Appiah, M. (2019). Impact of Illegal Mining Activities on Forest Ecosystem Services: Local Communities' Attitudes and Willingness to Participate in Restoration Activities in Ghana. *Heliyon*, *5*(10), e02617.
24. Sachs, J. D., & Warner, A. (1995). Natural Resource Abundance and Economic Growth.
25. Sakyi, P. A., Efavi, J. K., Atta-Peters, D., & Asare, R. (2012). Ghana's quest for oil and gas: Ecological risks and management frameworks. *West African Journal of Applied Ecology*, *20*(1), 57-72.
26. Tindan, P. D. (2013). The Causes of and Impact from Deforestation on Local Level Sustainable Forest Management in Ghana: a Survey of Dwease and Praaso Communities in the Ashanti region.
27. Viada, S. T., Graham, B. D., & VanGraafeiland, K. B. (2010, April). Large-Scale Habitat Mitigation for Seismic Operations Offshore Mozambique. In *SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production*. OnePetro.
28. Yalley, P. P., & Ofori-Darko, J. (2012, July). The effects of Ghana s oil discovery on land and house prices on communities nearest to the oil filed in Ghana (Case Study: Kumasi and Sekondi-Takoradi).

In *Procs 4th West Africa Built Environment Research (WABER) Conference, 24* (pp. 1443-1454).