# CONFLUENCE OR CONFLICT BETWEEN INDIGENOUS AND WESTERN SCIENTIFIC KNOWLEDGE ON CLIMATE CHANGE: THE CASE OF WA, GHANA

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## Abstract

How can indigenous and western scientific knowledge engage climate change dynamics collectively? The study addressed the question through the analysis of primary and secondary data. The primary data was sourced from key informant interviews, group discussion and questionnaire administered to 90 indigenes while the secondary data, which comprised statistics on temperature and rainfall, was obtained from the Wa weather station. The results revealed increasing temperature from 27.5$^{o}$C in 1970 to 28.6 $^{o}$C in 2010, an increase ranging between 1.1$^{o}$C – 1.6$^{o}$C, and compatible outcomes from the two knowledge claims. Other findings included increasing wet rains and decreasing dry rains. The net effect on rainfall showed a generally decreasing trend over the period 1961- 2011 at the rate of $y = -0.8685x + 1067.5$. However, indigenous indicators revealed increasing rainfall, confirming incompatible outcomes from the two knowledge sources. The two knowledge sources know climate and any change thereof from accumulated historical information. Indigenous knowledge does this through lived experiences in a repetitive process stored in oral tradition and symbols. Western scientific knowledge does the same through observation, measurement and analysis, of which reports are stored in hard form (paper copies) or soft form (digital copies). Therefore,

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incompatible outcomes raise questions about intrinsic values and weaknesses embedded in the separate methods.

**Keywords**: Climate change, indigenous, indicators, temperature, rainfall, Wa.

## Introduction

Climate, defined as the average weather condition of a place studied for over 30 years (Arguez and Vose, 2011:699), changes as the arithmetic mean of the weather elements (rainfall, temperature, relative humidity, air pressure, sunshine, wind speed and direction, visibility and cloud cover) show statistically significant differences persistently over a decade, a 30-year period, a century or even a millennium (CWT, 2007:30). The composite term, climate change, had endured global reaction since the Earth Summit in 1992, following the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) (Halvorssen, 2008). In terms of definitions of climate change, the IPCC emphasizes the use of statistical test of changes in the mean and/or variability in the weather elements persistent over an extended period while the UNFCCC stresses upon human and, to some extent, natural factors which alter the composition of the global atmosphere (IPCC, 2014). Whichever definition is used, climate change represents a multifaceted global challenge with accompanying social risks in the form of disaster risks (Lavell, Oppenheimer et al. 2012), exposure of various systems to the impacts (O'Brien and Leichenko 2000), causing various vulnerabilities (Fussel and Klein, 2006) and engendering several adaptations (Adger, Dessai et al. 2008).

The social aspect of climate change discourse highlights certainty and uncertainty (Whitmarsh, 2011); and triad positions as involving the dominant (which privileges climate change awareness creation by political actors), the oppositional skeptic stance (which doubts and questions climate change knowledge) and the emergent position (which is convinced of the occurrence of climate change and requires that remedial actions be based on justice and fair play) (Jamison, 2010). Then there are global power actors in support of climate change (European Union) or otherwise (United States of America), with special reference to the Kyoto Protocol (Lorenzoni and Pidgeon, 2006); those who advocate integrating biophysical and socio-economic indicators of climate change (Donatuto, Grossman et al. 2014); and others who argue for incorporating indigenous knowledge into climate change concerns to complement modern/western scientific knowledge and arrive at a global knowledge system (Ajani, Mgbenka et al. 2013).

The social climate change context has evolved around many standpoints based on values, worldviews and beliefs that fashion forms of denial and conviction (Wendling, Attari et al. 2013). Specifically, there are issues relating climate change to mental health (Doherty and Clayton, 2011), that climate change undermines human security and induces violent conflicts (Barnett and Adger, 2007), that climate change adversely affects both rich and poor countries (Ford and Berrang-Ford, 2011) and that climate change is increasing environmental migration (Gibb and Ford, 2012).

In Ghana, social climate change studies have investigated farmers' adaptation to climate change (Gyampo et al. 2009; Osei-Owusu et al. 2012; Codjoe et al. 2013). At the institutional level, climate change mitigation is the focus, and it involves mainstreaming climate change, capacity building and leadership development, early warning systems, climate change economics and finance as well as climate change knowledge management (UNDP-Ghana 2013). This paper contributes to the social climate change discourse. The aim is to identify intersections between two different knowledge production systems in science. The objective is to interrogate indigenous constructions of climate change and verify them with weather station data in order to improve upon knowledge on climate change. The critical question is: How can indigenous and western scientific knowledge engage climate change dynamics collectively? In exploring this question, this paper moves away from contesting debates on whether climate change is human-induced or not and rather adds field evidence to buttress the argument by various UN conventions for integrating indigenous knowledge in the study of environmental issues such as climate change (UNCCD, 1996; UNFCCC, 2014). An empirical basis for doing so, and the capacity of indigenous knowledge to predict environmental events are found in Huntington (2000). The ability, through integrating indigenous knowledge, to provide background information or explain environmental problems, which is often near impossible to do through the use of western scientific methods, is discussed by Forsyth (1996). The integration increases efficiency in the research process of cross-cultural interdisciplinarity (Sillitoe, 2000). The nomenclature on indigenous knowledge of climate change is a thesis on its own: "indigenous ecological knowledge, traditional ecological knowledge, traditional environmental knowledge, traditional knowledge and indigenous knowledge". Also, it is location specific, knowledge residing in a place and memory (Davies, 2011:116). This paper adds to the benefits of the critical realist approach, in which the role of science is to get it right (Peprah, 2014), in this specific case, about climate change.

The paper comprises five main sections. The introduction argues on the side of social climate change, specifically the incorporation of indigenous knowledge into climate change knowledge production. The next section reviews three theoretical frameworks and comes out with a conceptual framework to assess the integration of the two knowledge systems. Consequently, the specific place where both knowledge claims are produced is discussed as the study area and the methods followed in the study are explicitly laid down. Subsequently, the results of the study are categorized into two. There are indigenous people's indicators of climate change, which include sunshine, dryness, coldness, bushfire, rainfall as well as lightning and thunder. The rest involves the presence of trees and grass, occurrence of diseases, availability of drinking water and food as well as the taste of yam, indigenous rice and millet. The second results comprise temperature and rainfall analyses from meteorological data, 1961 – 2011.

## Theoretical Framework

The linkages between indigenous and western scientific knowledge have been explored by several studies. Knowledge by definition refers to justified true belief (Soini and Kronqvist, 2011). Science is a methodological process involving knowledge production through statistical analysis of data or instrumental records based on reliability, validity and reproducibility. Scientific knowledge implies facts or fact-like statements produced by scientific activity and community, while indigenous knowledge refers to knowledge accumulated over several generations by people living in a particular natural environment (Erickson, 2005; Alexander et al. 2011; Peprah, 2014). According to Green and Raygorodetsky (2010), indigenous knowledge is the bedrock of successful climate change adaptation and resilience. Hence, co-creation of knowledge would ensure social justice and an amelioration of the disproportionate share of the effects of climate change borne by indigenous people. Alexander et al. (2011) add that the integration of the two knowledge claims will strengthen and benefit both indigenous community and scientific study. Estimates show that there are 350 million indigenous people coming from 5,000 tribes and 70 countries in the world (Davis, 2010:3). The author reiterates the usefulness in considering rights, needs and knowledge of indigenous people on climate change mitigation as well as increasing indigenous groups' participation in climate change negotiations. In spite of studies calling for integration, Nakashima et al. (2012) posit that it is inappropriate to compare results of indigenous and western scientific knowledge claims on climate change because the two sources are incompatible; even though the object of study may be the same, the methods of study differ.

Figure 1 shows the representation of integration of indigenous and western scientific knowledge into climate change inquiry, as adapted from (Agnew and Goodess, 2005; Gearheard et al. 2009; Mercer et al. 2009). Climate change could be assessed in three ways: indigenous, western scientific and integrated inquiry. Different outcomes are generated depending on the method of assessment. Integrated inquiry produces compatible results that overlap and connect relatively easily but sometimes show limited agreement. However, the separate use of indigenous or western scientific analysis of climate observations may produce incompatible results. Such outcomes are complex in nature and may be incompatible. Inherently, there is feedback from the various outcomes to the three inquiry pathways and to the climate change dynamics.

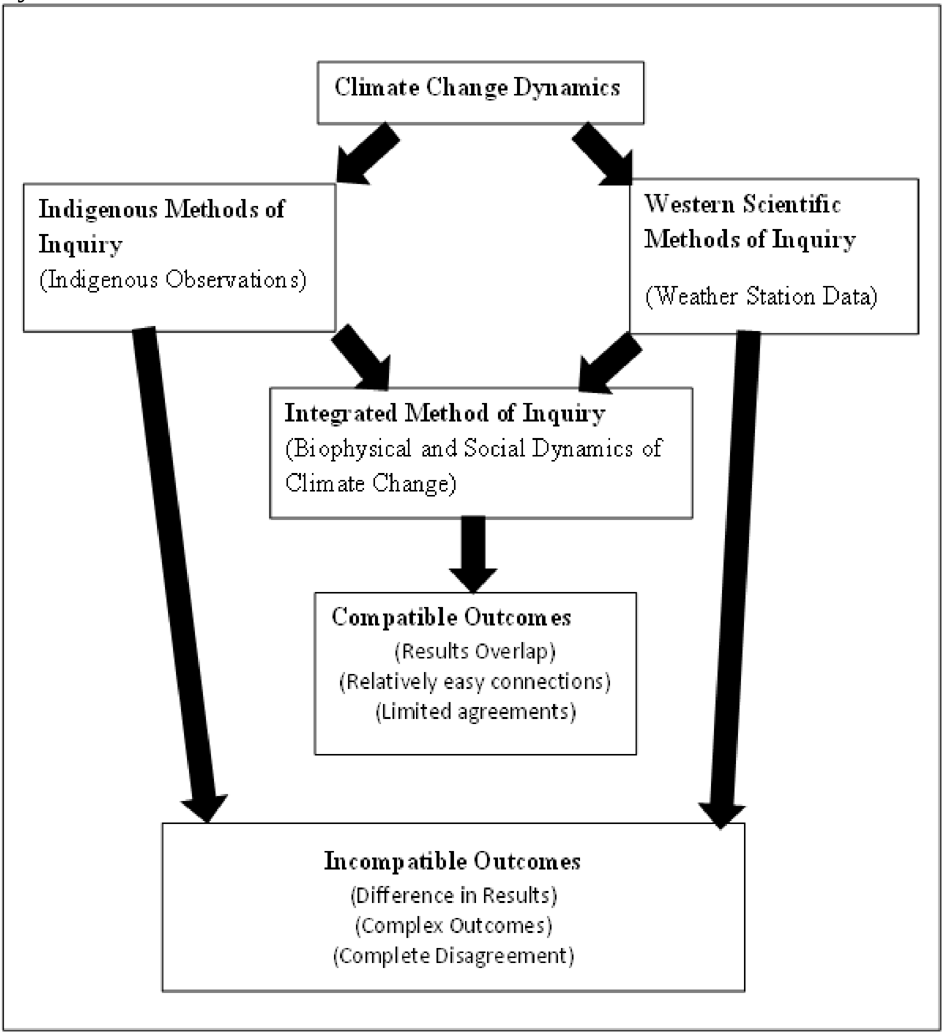


Figure 1. Conceptual Framework for integrating climate change inquiry

Source: Adapted from (Agnew and Goodess, 2005; Gearheard et al. 2009; Mercer et al. 2009)

## Study Area and Methodology

According to Ghana's urban hierarchy (metropolitan, municipal and district assemblies [MMDAs]), the study area, Wa, falls under municipal (Government of Ghana 2010) and occupies a land surface area of 234.74 $km^2$ constituting about 6.4% of the Upper West Region (Aduah and Aabeyir 2012:659). Wa is located on the coordinates of 9º50' N to 10º20' N and 1º40'W to 2º45' W. It shares administrative boundaries with Nadowli-Kaleo District to the North, Wa East District to the east and south and Wa West District to the west and south. The total number of people in Wa increased from 98,675 in 2000 to 119, 387 in 2006; to 107,214 in 2010; and 127,284 in 2012; while maintaining the proportions of 49% male and 51% female (Ghana Statistical Service 2012; Wa Municipal Assembly 2012; Peprah 2013:186).

The study proceeded on the lines of mixed methods; that is, the use of qualitative primary data in addition to quantitative secondary data (meteorological records). In sourcing the primary data, three techniques were used: key informant interviews, focus group discussion and questionnaires administered to 90 indigenes. Indigenous people's perspectives were grouped into two: early life of respondents (about 6-15 years designated as 'past') and old age (60+ years designated as 'present'). Questionnaire responses were entered into SPSS 18.0 as string data and analysed based on descriptive statistics using frequency of occurrence and percentages. Respondents were asked to assess past and present climate separately. This was to aid triangulation of responses. The 90 respondents assessed the climate on the scale of very low, low, moderate, strong and very strong separately for the past climate and for the present climate. Therefore, it would be inaccurate to sum up percentages of past and present climate data and expect to obtain one hundred percent. Low and very low were put together, as were strong and very strong. Past and present climate indicators for low, moderate and strong were compared to find out which had the highest and lowest responses, as reported in the next section. Chi-square analysis was performed to show differences or otherwise in the responses on the two time period: past and present. The *p* value was compared with an α value of 0.05. The null hypothesis is that there is no difference in past and present climate. For low *p* value, reject the null hypothesis. For high *p* value, maintain the null hypothesis. Schematic boxplot analysis under GenStat was used to assess central tendency in monthly rainfall.

## Results

## Indigenous People's Indicators of Climate Change

### Occurrence of Climate Change

All the 90 respondents acknowledged the occurrence of climate change. Table 1 shows the scale of affirmation where the largest percentage (32%) holds it to be moderate. This implies a change between the past and present climates.

Table 1. Ratings of Perception of Observance of Climate Change

| Occurrence of Climate Change | Frequency | Percent |
|---|---|---|
| Very low | 10 | 11 |
| Low | 22 | 25 |
| Moderate | 29 | 32 |
| Strong | 28 | 31 |
| Very strong | 1 | 1 |
| Total | 90 | 100.0 |

Figure 2 shows a summary of the indigenous climatic indicators. The length of the bar indicates the perspective of respondents regarding the past climate (when respondents were between age 6-15) and the present climate (when respondents have attained 60 years and above). Details of each indicator are provided in the sub-sections that follow.

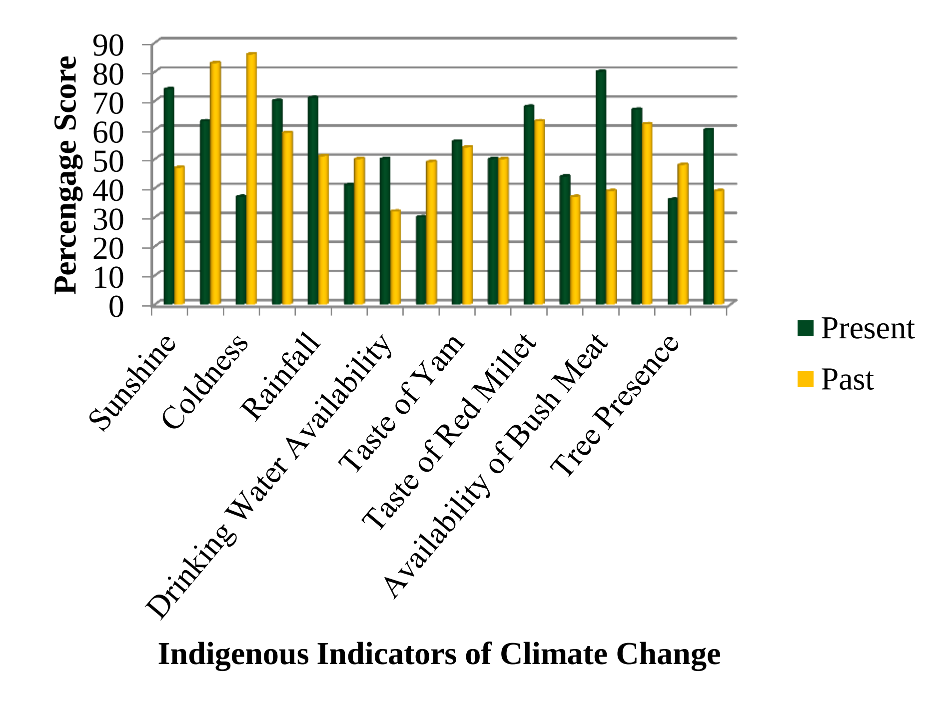


Figure 2. Summary of Perceptions on Performance of Indigenous Climatic Indicators

**Sunshine or dryness or coldness**

The indigenous people perceived sunshine to be intense. As to whether the sun shines with greater intensity in the present than in the past, 74% (67 out of 90) reported for the present and 47% (42 out of 90) for the past. The p value = .000, where $p < 0.05$; this implies that there was a statistically significant difference in sunshine over the two periods: past and present. An old woman in her 70s said: "…*in present days the sun shines as if God wants to burn down the earth*." Furthermore, concerning perceptions of the dry season (harmattan), 83% (75) thought it was more severe in the past while 63% (57) perceived it to be harsher in the present, with a p value = .000 where $p < 0.05$, supporting statistical difference in the responses.

Moreover, bushfires (the usual burning of the bush in the dry season) were reported to be strong, with a lower occurrence in the past, as reported by 59% (53), and an increased occurrence in the present, as testified by 70% (63), with a p value = .000 where $p < 0.05$; implying a statistical difference between the two responses.

In addition, coldness (winter coldness during the harmattan, i.e. winter in the northern hemisphere during the dry season) was considered to be strong both in the past (73.3%, 66) and in the present (85.6%, 77), with a p value = .009 where $p < 0.05$. Hence, the null hypothesis of no difference between the two groups (observed and expected count) and was rejected. This particular group appears to be averse with present global warming information and experience as well as with responses on the dry season.

**Rainfall or lightning and thunder or drinking water**

The respondents indicated that some animals, soil organisms, insects and birds provided signs that farmers used to determine the commencement of rainfall and the time for planting crops. According to the indigenes, the indicators were accurate, valuable and reliable. Study participants attributed the present absence of some animals to climate change. The general point was that the rains used to start in March and active farming in April. Currently, these dates are unpredictable because the young people cannot interpret the signs and there are inconsistencies in the start of rainfall. A respondent reported: "…*the rain comes at the time we do not need it and stops at the time we need it most*."

The indigenous people perceived increasing rainfall; some 51% (46) reported for the past and 71% (64) for the present, with a p value = .000 where $p < 0.05$; the null hypothesis was rejected. The measurement of rainfall was done using the amount of crops harvested. Other respondents quantify the rains by the level of some rivers and water bodies. With regards to lightning and thunder, indigenous people observed more occurrences of lightning and thunder in the past 50% (45) than the present 41% (37), with a p value = .000 where $p < 0.05$, described as a significant statistical difference between the two groups. Availability of drinking water was higher in the present (50%) than the past (32%); an admittance of improved water supply in the present over the past, with a p value = .043 where $p < .05$; implying a statistical difference between the past and the present. The respondents were united on these statements on the water situation in the past:

> …getting water during the harmattan season was very difficult and women used to walk so many miles to access water which was not even potable but we had to use it… before a woman could get one pot of water during the dry season, she would have to use the whole day due to the distance and the number of women who would be at the well or dugout waiting for the water to spring out.

**Other indigenous indicators of climate change**

There was more food in the past as reported by 49% (44) than in the present as testified by 30% (27), signifying the incidence of hunger presently, with a p value = .340 where $p > 0.05$. Hence, the null hypothesis was not rejected (34% > 5%). It was reported that farmers used to harvest crops in August. Locally, August is nicknamed in the Dagaare language as "Oguri", meaning "so much to chew". The harvesting of maize, groundnuts, beans and other early maturing crops indicated a lot of food literally for "chewing". The respondents lamented: "*... nowadays, harvesting starts in late September, October or sometimes November*".

One respondent had this to say:

> …my father used to farm 3 acres of land and harvest 10 bags of maize and about 6 bags of millet on the same plot without using any fertilizer or chemical…now I usually

> use fertilizer, insecticide and herbicide on the same piece of land yet I cannot get up to 4 bags of maize, [not] to talk of millet.

However, due to adaptation measures, most indigenous people indicated that hunger does not strike so many people in the harmattan. Due to the availability of motorable roads linking the north with the south, northern migrants in southern Ghana do foodstuff remittance, commonly maize, dry cassava flour and yam tubers. The taste of indigenous yam (*Dioscorea sp*.) recorded 54% (49) in the past whilst the present figure is 56% (50); with the $p$ = .000 and $p < 0.05$, suggesting a statistical difference between the two answers. The taste of white millet (*Pennisetum americanum*) has not changed, as reported by 50% (45) for the past and 50% (45) for the present. However, the taste of red millet (*Pennisetum americanum*) has improved, as confirmed by 63% (57) for the past and 68% (61) for the present, with $p$ = .000 where $p < 0.05$, indicating a statistical difference in the two views. Also, the taste of indigenous rice (*Oryza sativa*) has improved, as affirmed by 37% (33) for the past and 44% (40) for the present, with p = .000 where $p < 0.05$, describing a statistical difference in taste over the two periods. Furthermore, prevalence of diseases during harmattan (e.g. the outbreak of cerebrospinal meningitis) was confirmed by 62% (56) for the past and 67% (60) for the present, with $p$ = .000 and $p < 0.05$, recording a statistical difference for the two responses. Additionally, the results revealed that the presence of trees was lower in the past (36%, 32) than in the present (48%, 43) with $p$ = .000 and $p < 0.05$, implying a rejection of the null hypothesis that there is no significant difference between the past and present. Likewise, the presence of grass cover in Wa was regarded by 39% (35) as lower in the past and by 60% (54) as lower in the present, with $p$ = .000 and $p < 0.05$, indicating a statistical difference between the two results.

## Scientific Evidence on Climate Change

A review of the literature showed an increase in temperature over a 40-year period: from 27.5$^o$C in 1970 to 28.6 $^o$C in 2010, indicating an increase of 1.1$^{o}$C with a temperature increase ranging between 1.1$^{o}$C and 1.6$^{o}$C (Rademacher-Schulz and Mahama 2012:61, 63). These figures confirm the indigenous proxy indicator of increased temperature, that is, increased sunshine. It appears the increasing temperature trend will continue in the future (Techie-Obeng et al. 2010:10); with near-future (2045-2065) and in the far-future (2081-2100), exhibiting an annual mean of 2.0 $^{o}$C and 3.9 $^{o}$C correspondingly; with a minimum annual mean of 2.2 $^{o}$C and 4.2 $^{o}$C respectively and a maximum annual mean of 2.1 $^{o}$C and 4.0 $^{o}$C respectively.

Figure 3 shows a schematic boxplot of monthly rainfall (1961 – 2011) that focuses on the shape of distribution, median, data variability and outliers. Whenever the median is located beyond the exact-mid portion of the box, that is, whenever the median is higher or the top whisker is longer than the bottom one, a lot more rainfall was received in the top 50% than the bottom 50%, as shown in the case of August. Also, the longer parts of the box and whisker imply that the rainfall data showed a greater range, while the shorter portion of a box indicated that values in the data were closely packed.

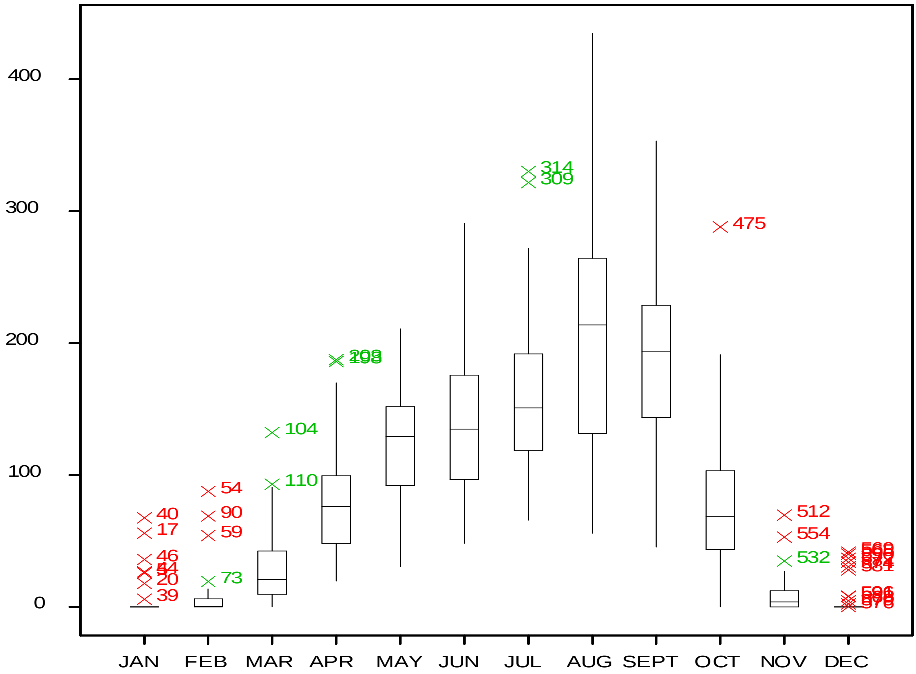


Figure 3. Schematic boxplot of monthly rainfall of Wa (1961 – 2011).

Figure 4 displays time series of annual rainfall (1961 – 2011), depicting a general decreasing trend indicated by y = -0.8685 x +1067.5; the year 1986 revealed the lowest rainfall, while 1963 showed the highest rainfall.

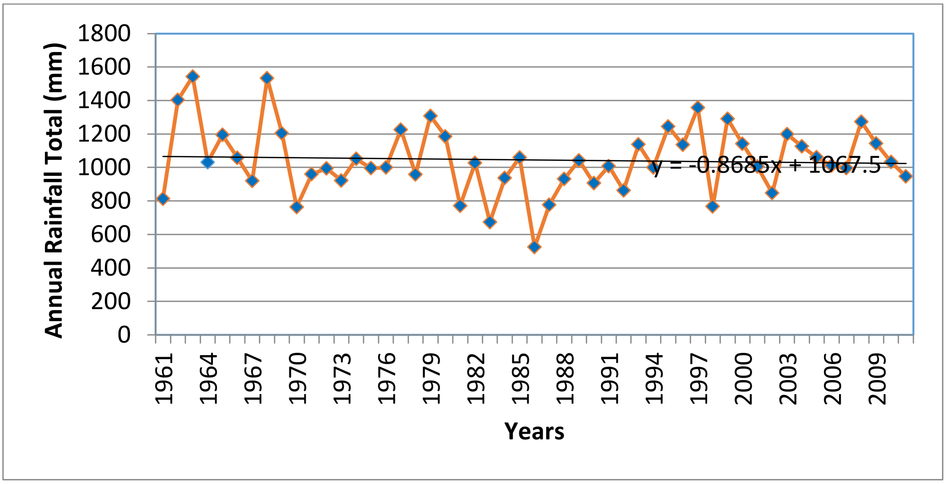


Figure 4. Annual Rainfall Total (mm) 1961 – 2011.

Figure 5 shows a rainfall graph for the dry season (called harmattan) calculated as rainfall in the months of October + November + December + January + February + March. The trend line indicates a decreasing dry season rainfall at a rate of y = -1.0837x +161.53, indicating the driest year as 1961 and the least dry year as 1976. The emphasis is on minimum rainfall.

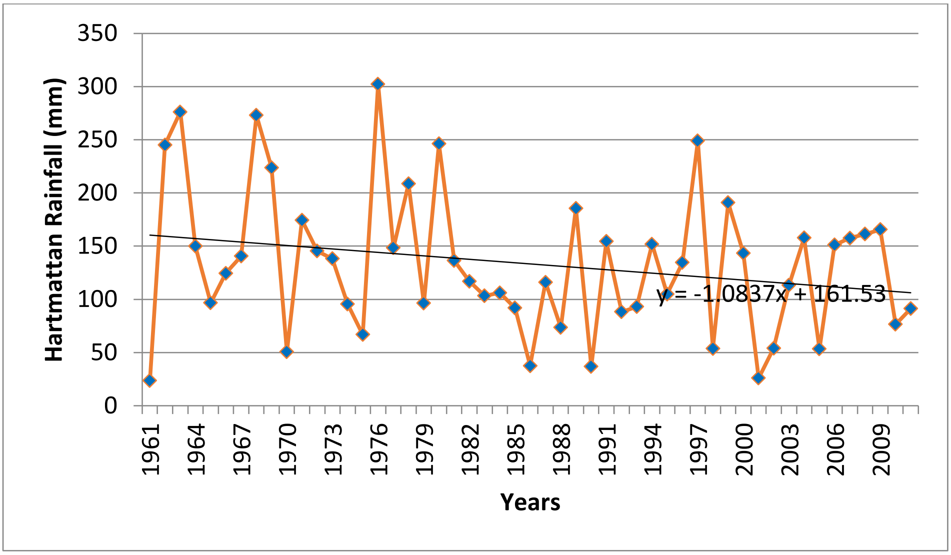


Figure 5. Harmattan rainfall (mm) 1961 – 2011.

Figure 6 depicts rainfall values for the raining season comprising the months of April + May + June + July + August + September. The trend line shows an increasing rainfall rate of y = 0.2152 x + 906.01, with the lowest in 1986 and the highest in 1963.  The mean maximum monthly rainfall (1961 – 2011) is represented by extracting maximum rainfall values from the total rainfall.

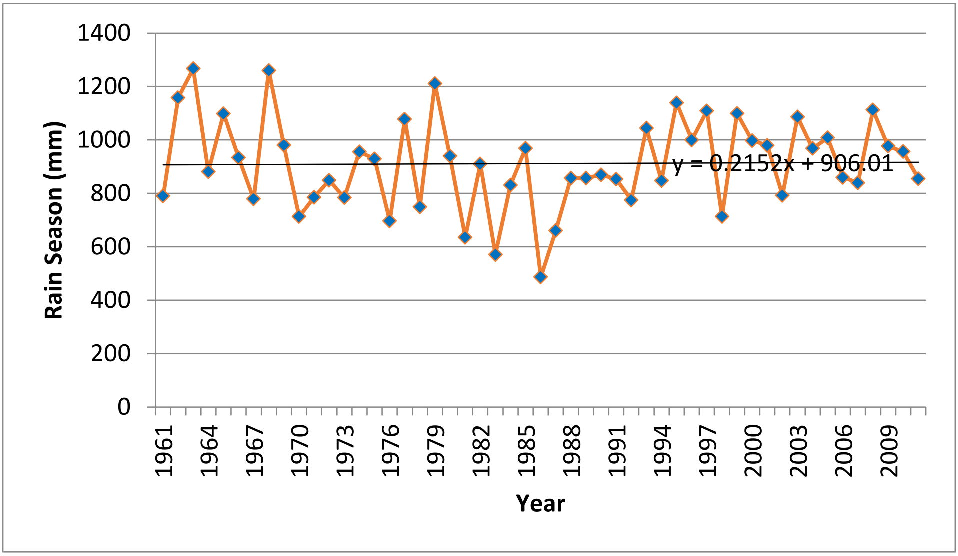


Figure 6. Rain season rainfall (mm) 1961 – 2011.

Figure 7 shows 50 years of rainfall in Wa categorized into five decades depicting clear variability. The third decade looked characteristically different from the rest. Although August rainfall was the most dominant in four of the decades, September and July rainfall was much higher than that of August in the second decade. The first three decades showed some amount of December rainfall. The remaining two decades (four and five) displayed no rainfall in December. Also, March rainfall indicated a regular reduction from the first to the fifth decade.

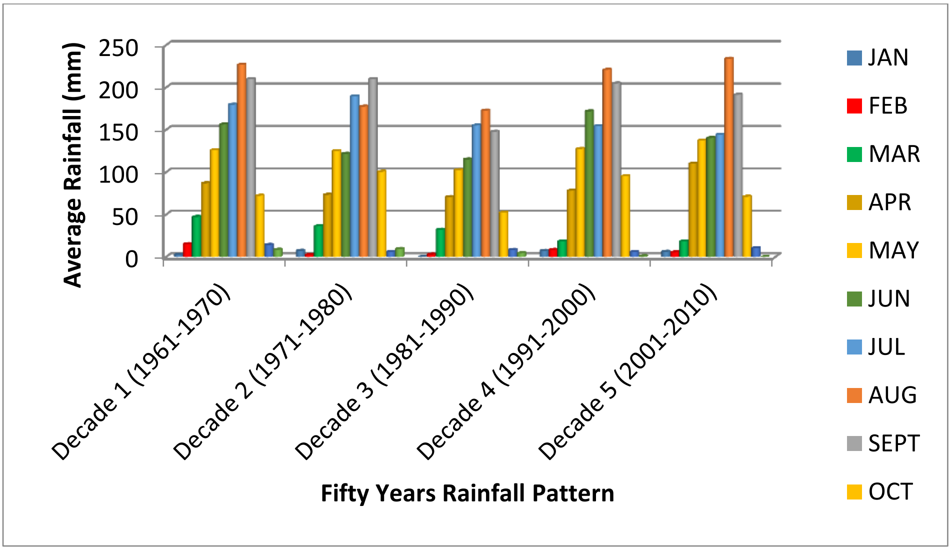


Figure 7. Decadal analysis of 50 years rainfall data of Wa synoptic weather station

## Discussion

## Climate Change Dynamics

The purpose of this paper is to validate the claims of indigenous people on the occurrence of climate change using temperature and rainfall data from Wa synoptic weather station. The findings suggest mixed outcomes. On the one hand, temperature results of both indigenous and western scientific methods of inquiry overlap. Both knowledge sources pointed to increasing temperature. On the other hand, rainfall results show difference outcomes. Indigenous observation claims that rainfall is increasing while western scientific rainfall data analysis shows a decreasing trend of rainfall over the 50 years (1961-2011). The different outcomes notwithstanding, the indigenous claim on rainfall cannot be said to be wrong since an analysis of rainfall values for the raining season (April, May, June, July, August and September) for the 50 years (1961-2011) shows an increasing trend.

## Indigenous Methods of Inquiry

Indigenous methods of assessing climate change dynamics use obvious traditional indicators, many of which are not directly related to climate but indirectly depend on the climate for survival or functioning. Many of the indicators are linked to the climate, e.g., sunshine, dryness, coldness, rainfall, lightning and thunder, as well as drinking water produced mainly from rainfall. Boon and Ahenkan (2012) also found that indigenous people perceive climate change through changes in rainfall pattern and prolonged dry season. Invariably, crops, the source of food, depend on climate for sustenance. Hence, the behaviour of crops is readily used by indigenous people to indicate changing climate, this is corroborated by Gyampo et al. (2009). In addition, the prevalence of diseases, particularly in the dry season, as well as the characteristics of the vegetation, particularly the presence of trees and grass cover, help indigenous people to mark climate change.

## Western Scientific Methods of Inquiry

The western scientific methods analyze climate data on rainfall, temperature, relative humidity, air pressure, sunshine, wind speed and direction, visibility and cloud cover, based on reliability, validity and reproducibility, to show persistent deviations from the normal as variation or change in the prevailing climate. This method is applied by various ecological departments in universities worldwide, research organizations, individuals and groups such as UNFCCC and the IPCC. For instance, the 2014 assessment and management of climate change risks was based on large scientific literature (IPCC 2014).

## Integrated Method of Inquiry

The integrated method of inquiry into climate change dynamics appears to be the ideal assessment procedure advocated by many studies. The strength and benefits of combining indigenous and western scientific methods of investigation have been discussed variously (Agnew and Goodess, 2005; Gearheard et al., 2009; Mercer et al., 2009; Davis 2010; Green and Raygorodetsky 2010; Alexander et al., 2011). A further significance of the integrated method is that climate change dynamics deal with both social and biophysical processes and phenomena which are not static but change over time. Hence, the integrated method of inquiry needs regular improvement to adequately operate well.

## Compatible Outcomes

All 90 indigenous respondents affirm the occurrence of climate change. Although IPCC (2014) uses low, medium and high to assess the level of agreement, the present study used very low, low, moderate, strong and very strong; about 88% was spread among low, moderate and strong occurrence. There was correspondence between indigenous indicators and western scientific climate analysis showing decreasing temperature. Probably, with the daily rising and falling of the sun, the heat intensity of the sun becomes obvious to the indigenous observer, contrary to rainfall which pours in a particular season and even occurs erratically during the season. The results is complemented by Ajani et al. (2013) who argued that indigenous knowledge and scientific proof are equally necessary to support climate change programmes.

## Incompatible Outcomes

The analyses of rainfall data clearly distinguishes two seasons: a raining season of six months (April, May, June, July, August and September) and a dry season of six months (October, November, December, January, February and March). However, the schematic boxplot confirmed four dry season months (November, December, January and February), and the shape of the box and whisker emphasize December and January as the driest months within the period (1961 – 2011). The long term trend in total annual rainfall (mm) is decreasing, although the raining season annual total is increasing; the dry season total is decreasing at a higher rate and feeds into the overall total annual rainfall decline. However, indigenous people observed increasing rainfall. A problem is created in a situation with such different outcomes. Which method is correct and which method is wrong?

The western scientific method with its rigorous empirical approach is often preferred to the indigenous method when a decision is to be made based on just one of the outcomes. This is so because there is evidence over a 50 year history of the western scientific method getting it right. The indigenous method may not be equally accurate due to the differences in the observers (study respondents) in terms of age and experience with climate issues. Often, the largest percent is deemed right irrespective of the composition of that specific majority. However, Gearheard et al. (2009) points out that the western scientific method sometimes uses data that is not representative of region. Hence, extrapolation is employed to cover areas with inadequate or no data. As a result, both methods come with certain intrinsic weaknesses which make it difficult to fault solely the indigenous method for the incompatible outcomes.

## Conclusion

The changing climate has to be assessed by an equally dynamic method of inquiry. Both the indigenous and western scientific methods contain various weaknesses. However, the western scientific method is the most preferred method. The long history of reliable and reproducible outcomes is enough justification to base climate decisions on such a method. However, history also shows that the western scientific methods have benefited from indigenous knowledge in several ways. Hence, an integration of methods is justified based on the social justice argument; the fact that indigenous societies do not participate much in the creation of anthropogenic climate change; and the disproportionate burden of consequences borne by indigenous societies due to reduced resilience and increased vulnerability. Again, the integrated method stands a better chance of assessing climate change in both the social and biophysical dynamics. Due to variation in personnel, instruments, experience, and climate processes and phenomena, differences in outcomes may arise with the use of separate or combined indigenous and western scientific methods. As posited by Gearheard et al. (2009), the differences in result may raise critical questions which, when addressed, will improve the climate change assessment.

Climate change represents a global environmental challenge but exerts localized effects on societies and people. Hence, vulnerabilities, resilience and adaptations are very relevant at the fine scale level. The merits and demerits of climate change mitigation find justification at the local actors' locations (site-specific), where prior indigenous experiences with the climate have a great influence on the prospects of climate change projects.

After all, the two knowledge sources know climate and any change thereof from accumulated historical information. Indigenous knowledge does this through lived experiences in a repetitive process stored in oral tradition and symbols. Western scientific knowledge does the same through observation, measurement and analysis, in which reports are stored in hard form (paper copies) or soft form (digital copies). Methods of analyzing the two historical accounts on the climate simultaneously become important. The conceptual framework of this study supports the use of an integrated method of inquiry. The basis is that weather station data analysis indicates that the raining season (April, May, June, July, August and September) is getting wetter with increasing rainfall. The dry season (October, November, December, January, February and March) is getting drier with increasing temperature and declining rains. Indigenous knowledge claims from this study corroborate these findings.

## References

Adger, W. N., S. Dessai, et al. (2008). "Are There Social Limits to Adaptation to Climate Change?" *Climate Change: Springer* 93: 335-354.

Aduah, M. S. and R. Aabeyir (2012). "Land Cover Dynamics of Wa Municipality, Upper West Region of Ghana." R*esearch Journal of Environmental and Earth Sciences* 4(6): 658-664 http://maxwellsci.com/print/rjees/v654-658-664.pdf.

Agnew, M. and C. Goodess (2005). "Developing a Conceptual Framework." University of East Anglia, UK:

*www.cru.uea.ac.uk/projects/circe/concept_framework_2ndDRAFT.doc*

Ajani, E. N., R. N. Mgbenka, et al. (2013). "Use of Indigenous Knowledge as a Strategy for Climate Change Adaptation among Farmers in sub-Saharan Africa: Implications for Policy." *Asian Journal of Agricultural Extension, Economics & Sociology* 2(1): 23-40.

Alexander, C., N. Bynum, et al. (2011). "Linking Indigenous and Scientific Knowledge of Climate Change." *BioScience* 61: 477-484.

Arguez, A. and R. S. Vose (2011). "The Definition of the Standard WMO Climate Normal." *BMS: 699-704.*

Barnett, J. and W. N. Adger (2007). "Climate Change, Human Security and Violent Conflict." *Political Geography: Elsevier* 26: 639-655.

Boon, E. and A. Ahenkan (2012). "Assessing Climate Change Impacts on Ecosystem Services and Livelihoods in Ghana: Case Study of Communities around Sui Forest Reserve." *Ecosystem & Ecography* S3: 1-8.

Codjoe, F. N. Y., C. K. Ocansey, et al. (2013). "Climate Change Awareness and Coping Strategies of Cocoa Farmers in Rural Ghana." *Journal of Biology, Agriculture and Healthcare* 3(11): 19-29.

CWT (2007). Climate Change 2007: Synthesis Report. Valencia, Spain, IPCC Plenary XXVII**:** 1-52.

Davies, M. (2011). "I Live Somewhere Else but I've Never Left Here" Indigenous Knowledge, History, and Place." *Counterpoints* 379: 113-126.

Davis, S. H. (2010). "Indigenous Peoples and Climate Change." *The International Indigenous Policy Journal* 1(1(2)): 1-17.

Doherty, T. J. and S. Clayton (2011). "The Psychological Impacts of Global Climate Change." *American Psychologist* 66(4): 265-276.

Donatuto, J., E. E. Grossman, et al. (2014). "Indigenous Community Health and Climate Change: Integrating Biophysical Social Science Indicators." *Coastal Management* 42: 355-373.

Erickson, M. (2005). *Science, Culture and Society: Understanding Science in the Twenty-First Century*. Cambridge, Polity.

Ford, J. D. and L. Berrang-Ford (2011). "Climate Change Adaptation in Developed Nations: From Theory to Practice." *Advances in Global Change Research: Springer Science:* 21-32.

Forsyth, T. (1996). "Science, Myth and Knowledge: Testing Himalayan Environmental Degradation in Thailand." *Geoforum* 27(3): 375-392.

Fussel, H. M. and R. J. T. Klein (2006). "Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking." *Climate Change Springer* 75: 301-329.

Gearheard, S., M. Pocernich, et al. (2009). "Linking Inuit Knowledge and Meteorological Station Observations to Understand Changing Wind Patterns at Clyde River, Nunavut." *Climate Change*.

Ghana Statistical Service (2012). *2010 Population and Housing Census: Summary Report of Final Results*. Accra, Ghana Statistical Service**:** 1-117.

Gibb, C. and J. Ford (2012). "Should the United Nations Framework Convention on Climate Change Recognize Climate Migrants." *Enrion. Res. Lett.* **7**: 1-9.

Government of Ghana (2010). Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda. Accra, Government of Ghana**:** 1-278.

Green, D. and G. Raygorodetsky (2010). "Indigenous Knowledge of a Changing Climate." *Climate Change* 100: 239-242.

Gyampo, B. A., S. Amisah, et al. (2009). "Using Traditional Knowledge to Cope with Climate Change in Rural Ghana." *Unasylva* 60(231/232): 70-74.

Halvorssen, A. M. (2008). "UNFCCC, The Kyoto Protocol, and the WTO - Brewing Conflicts of are They Mutually Supportive?" *Denv. J. Int'l L. & Pol'y* 36(3/4): 369-379.

Huntington, H. P. (2000). "Using Traditional Ecological Knowledge in Science: Methods and Applications " *Ecological Applications* 10(5): 1270-1274.

IPCC (2014). Climate Change 2014 Impacts, Adaptation, and Vulnerability: Cambridge and New York: Cambridge University Press.

Jamison, A. (2010). "Climate Change Knowledge and Social Movement Theory." *Climate_Change: Springer* 1: 811-823.

Lavell, A., M. Oppenheimer, et al. ( 2012). Climate Change: New Dimensions in Disaster Risk, Exposure, Vulnerability, and Resilience. Cambridge and New York: Cambridge University Press.

Lorenzoni, I. and N. F. Pidgeon (2006). "Public Views on Climate Change: European and USA Perspective." *Climate Change: Springer* 77: 73-95.

Mercer, J., I. Kelman, et al. (2009). "Framework for Integrating Indigenous and Scientific Knowledge for Disaster Risk Reduction." Overseas Development Institute/ Blackwell Publishing.

Nakashima, D. J., K. Galloway McLean, et al. (2012). Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. Paris, UNESCO and UNU.

O'Brien, K. I. and R. M. Leichenko (2000). "Double Exposure: Assessing the Impacts of Climate Change within the Context of Economic Globalization." *Global Environmental Change: Pergamon* 10: 221-232.

Osei-Owusu, Y., R. M. Al-Hassan, et al. (2012). Assessing the Adaptation Mechanisms of Smallholder Farmers to Climate Change and Agrobiodiversity Losses in Northern Ghana. Accra, START/Conservation Alliance: 1-359.

Peprah, K. (2013). "Sand Winning and Land Degradation: Perspective of Indigenous Sand Winners of Wa, Ghana " *Journal of Environment and Earth Science* 3(14): 185-194.

Peprah, K. (2014). "Knowledge Production Contest between Natural and Social Scientists with Regards to Land Degradation Assessment." *The Journal of Arts and Philosophy* 2(1): 5-11.

Rademacher-Schulz, C. and E. S. Mahama (2012). Where the Rain Falls project. Case Study: Ghana Results from Nadowli District, Upper West Region. Rainfall, Food Security and Human Mobility Case Study: Ghana. Bonn, United Nations University Institute for Environment and Human Security (UNU-EHS). 3: 1-132.

Sillitoe, P. (2000). "Let Them Eat Cake: Indigenous Knowledge, Science and the "Poorest of the Poor." *Anthropology Today* 16(6): 3-7.

Soini, H. and E. Kronqvist, Eds. (2011). Epistemology - A Tool or a Stance. Qualitative Psychology Nexus VIII Epistemologies for Qualitative Research. Tubingen, Germany, Die Deutsche Bibliothek.

Techie-Obeng, E., E. Gyasi, et al. (2010). Farmers' Adaptation Measures in Scenarios of Climate Change for Maize Production in Semi-Aric Zones of Ghana. 2nd International Conference: Climate, Sustainability and Development in Semi-Arid Regions. Fortaleza - Ceara, ICID +18**:** 1-20.

UNCCD (1996). About the Convention Part I. Bonn, Germany, United Nations Organization**:** http://www.unccd.int/en/about-the-convention/Pages/Text-Part-I.aspx.

UNDP-Ghana (2013). Africa Adaptation Programme in Ghana. Accra, UNDP-Ghana**:** 1-8.

UNFCCC (2014). Reporting on the Meeting on Available Tools for the Use of Indigenous and Traditional Knowledge and Practices for Adaptation, Needs of Local and Indigenous Communities and the Application of Gender-Sensitive Approaches and Tools for Adaptation. Bonn, United Nations**:** 1-63.

Wa Municipal Assembly (2012). The Composite Budget of the Wa Municipal Assembly for the Fiscal Year 2012. Wa, Ministry of Local Government and Rural Development**:** 1-109 http://www.mofep.gov.gh/.

Wendling, S. A., S. Z. Attari, et al. (2013). "On the Importance of Strengthening Moderate Beliefs in Climate Science to Foster Support for Immediate Action." *Sustainability* 5: 5153-5170.

Whitmarsh, L. (2011). "Scepticism and Uncertainty about Climate Change: Dimensions, Determinants and Change over Time." *Global Environmental Change* 21: 690 - 700.