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Critical findings of the sixth assessment report (AR6) of working Group I of the intergovernmental panel on climate change (IPCC) for global climate change policymaking a summary for policymakers (SPM) analysis

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Abstract

Purpose – The purpose of this study is to assess how intergovernmental panel on climate change's (IPCC's) sixth assessment report of Working Group I (WGI), a Summary for Policymakers (SPM), has evaluated the current climate change situation. The author uses the qualitative content analysis (QCA) method (i.e. summative content analysis [SCA]) to identify critical points of the SPM.

Design/methodology/approach – To better understand the WGI report and its SPM, the author uses the thematic analysis, often called the QCA method. This study takes more steps and uses one of the main qualitative content analysis approaches (i.e. SCA). Therefore, QCA (SCA) can help the author count the occurrence of certain words using computer-assisted qualitative data analysis software that quantifies the words in the data. This process helps the author to understand codes and patterns (e.g. the concept in the results section).

Findings – Interestingly, the AR6 says more about adaptation for policy makers in sections C (Climate information for risk assessment) and D (Mitigation of future climate change) than in sections A and D. Finally, this study concludes that the IPCC WGI SPM has addressed evidence on global climate change policymaking for SPMa, SPMd (mitigation-based strategies and mitigation policy [MP]) and SPMb, SPMc (adaptation policy and adaptation-based strategy).

Research limitations/implications – First, this study refers only to the contribution of WGI, a SPM. The findings of this study do not necessarily provide a full understanding of what the AR6 WGI SPM says about climate change. It points out that the QDA Miner software and Voyant tool do not include all variables and examples where mitigation and adaptation-based strategies are discussed. The guidance for coding is based on the approved version of IPCC AR6 WGI SPM. The final limitation is that the relatedness of key words (e.g. confidence, high and warming) is sometimes ambiguous; even experts may disagree on how the

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words are linked to form a concept. Thus, this method works at the keyword level. A more intelligent method would use more meaningful information than keywords.

Originality/value – This study used qualitative data analysis (SCA) to explore what was said about climate change in four sections of the IPCC AR6 WGI SPM, which may influence current and future global climate change policymaking.

Keywords IPCC, Policymaking, SPM, Adaptation, Mitigation

Paper type Research paper

1. Introduction

The summary for policymakers (SPM) summarizes the intergovernmental panel on climate change (IPCC) reports that intended to aid policymakers and is approved line by line by governments (IPCC, 2007). The SPM document and information can be important for European policy assessment, implications of climate change and good quality of human life (Ryu *et al.*, 2020; Kundzewicz *et al.*, 2008), but some of this information is beneficial for the impacts of climate change on land and land use (Englund *et al.*, 2020). Following Barkemeyer *et al.* (2015), the author used an analysis of IPCC summaries for policymakers to understand the critical points of the IPCC sixth assessment report of Working Group I (WGI) SPM. There is an increasing debate that WGI is an essential and powerful tool for understanding current climate change challenges and for governments' communication at the international level (Stocker and Plattner, 2016; Black, 2015). This importance was recognized by states and activists in WGI's IPCC sixth assessment report: a SPM (IPCC AR6 WGI, 2021). Thus, The WGI analysis provides scientific data relevant to meet the challenge of global climate change. WGI looks at variability and changes which is related to Working Groups II. The policy dimensions of WGI are the assessment of climate and energy targets; interactions between land and the climate; and links between climate and air quality. All of these aspects are closely connected with the assessment of WGIII and strategies to mitigate against the impacts of climate change. The WGI assessment combines theory and assessment of policy.

SPM in sixth assessment report (AR6) (August 9, 2021) has specific sections on the physical science basis. The Physical Science Basis SPM is an essential chapter of the full report, as it focuses exclusively on four concepts. The first category is connecting to climate change, second to possible climate futures, third to climate information for risk assessment and regional adaptation and, finally, limiting future climate change. The present article shows how IPCC's sixth assessment report (WGI) (Masson-Delmotte *et al.*, 2021) has assessed the climate change situation which can potentially influence the Global Climate Change Policymaking (GCCPM)? Through this question, the article assesses which type is associated with mitigation and adaptation to determine whether the WGI SPM is with future global climate change reports and policies. The author decides to pay particular attention to Qualitative Content Analysis (QCA) techniques for analysis. Thus, the structure of the article is as follows. In the first section, the author reviews and explains the IPCC briefly. Second, techniques of analysis and materials (qualitative data analysis software) are discussed, and in the third step, the results and discussion that analyze main four categories and concepts are presented. The final section provides conclusions for the AR6 WGI SPM.

2. Scope of research: Desk-based literature review of IPCC (AR6)

This section is a review of the case study (AR6 WGI SPM), which provides an overview for reader about next sections (i.e. analysis and findings). To improve the general understanding of this study, the author conducted desk-based review (Iuliano *et al.*, 2020;

Aceijas and Rhodes, 2007) and looks at the research papers, reports and documents that have already been published.

Like previous Assessment Reports (e.g. IPCC AR4, FAR5), The Sixth Assessment Report (AR6) consists of three Working Group contributions and a Synthesis Report, which integrates the Working Group assessments and the Special Reports produced during the cycle (IPCC Secretariat c/o World Meteorological Organization, 2020). This research will focus on AR6 WGI to review and understand the current climate change situation. The WGI assessment combines observations, palaeoclimate, process studies, theory and modeling into a complete picture of the climate system and its change, including the attribution (or causes) of change (Working Group I – IPCC, 2021). IPCC released its following report titled "Climate Change 2021: the Physical Science Basis" on August 9, 2021. This report is the WGI Contribution to the AR6. It releases following an approval session held remotely to consider the document from July 26 to August 6 (IPCCIPCC AR6 Report (WG1 Contribution): Climate Change 2021-The Physical Science Basis | SDG Help Desk, 2021). With the release of AR6 and Contribution of WGI, the author of this research addresses the SPM and identifies critical findings following the scope of the analysis section.

3. Scope of analysis and materials

3.1 Method

To better understand the WGI report and its SPM, the author uses the Thematic Analysis (TA), often called the QCA method. Sometimes research requires qualitative data to be measured when most of the research data is qualitative; thus, this is where QCA comes into research assessment. QCA in doing research is one of the most used methods for analyzing qualitative data (Guest *et al.*, 2012; Schreier, 2012; Kuckartz, 2014).

The analysis of text-as-data is a growing scope of interest in political science and public policy research. Some scholars (Hopkins and King, 2010) move toward quantitative methods to examine the growing amount of text data. These methods are becoming widely available through social media and political events (Young and Soroka, 2012; Grimmer and Stewart, 2013; Wilkerson and Casas, 2017). Researchers use QCA to scale the text's classification (Hsieh and Shannon, 2005; Onwuegbuzie *et al.*, 2015). The author applies QCA techniques for the classification of text (Hsieh and Shannon, 2005; White and Marsh, 2006; Elo and Kyngäs, 2008) of the AR6 WGI report revealing data in words and concepts. Specifically, the author will concentrate on computer-assisted tools (i.e. computer-assisted qualitative data analysis software [CAQDAS]) and focus on the characteristics of sentences (e.g. words) with attention to the content or contextual meaning of the text. QCA in this research is used for the abstraction process where the author recognizes a set of words that describe essential things in content and data (i.e. concepts). Thus, while previous studies of QCA did take a primary method to have an assessment, this research takes more steps and uses one of the main qualitative content analysis approaches (i.e. summative content analysis [SCA]) (Schaaf *et al.*, 2022) .

The first part of the AR6 Report, Climate Change 2021: The Physical Science Basis, the WGI was screened by QDA Miner software (i.e. authors, tables, figures, symbols, frequently asked questions, cite, quote, annex, glossary and references). It resulted in 2,573,135 total words and 63,288 unique word forms. Based on QCAAs (i.e. SCA), the author used Natural Language Processing(NLP) for comprehension of incomplete sentences, meaningless words, text in the tables, references and spaces. The author uses the tokenization technique (based on NLP) to make meaningful relations between extracted words. Tokenization is the step that identifies the complete minor units within a text, usually the most important words, and sentence detection. After this process, the author seeks the frequency of words to shape the central

concept(s). Therefore, to reflect how important a word is in this report, the author uses Term Frequency-Inverse Document Frequency (TF-IDF) (an information retrieval technique) that weighs a TF and its IDF in text mining (QDA Miner software).

3.2 Data analysis

The data analysis in this research consists of three phases: data cleaning, text clustering and text analysis by the software tool [i.e. Computer-Assisted Qualitative Data Analysis Software (CAQDAS)] (Rademaker *et al.*, 2015). CAQDAS can help the author to clean the data, namely, remove the technical summary, authors, the annexes and the supplementary materials. Thus, the central unit of analysis is SPM (IPCC, 2021). The unit of analysis refers to the basic unit of text classifying during content analysis (Wang *et al.*, 2000; De Wever *et al.*, 2006; White and Marsh, 2006). The selected unit – SPM – was classified in the second phase based on titles and their contents (e.g. the current state of the climate). The author derives the categorization of the text from Dezdar and Sulaiman (2009), Snelson (2016) and Kobayashi *et al.* (2017) to (re)ensure the coding and software analysis. The author has considered QDA Miner software and Voyant Tool (CAQDAS) (Sutton and Austin, 2015; Kuckartz and Rädiker, 2019).

The author argues that a large topic format with technical information is complex to be assessed by CAQDAS and presents critical points (Bazeley, 2013; Bandara *et al.*, 2015) and arguments. Thus, the classified sections were coded. The author argues that multi-level coding, inductive versus deductive, can assist in understanding the core of classified sections, implementation of the central frames and subsequent modification of the coding frame (i.e. SPMa, SPMb, SPMc and SPMd). Hence, the author identified the appearance of the abovementioned four frames through QCA (SCA) and a close review of the text. Then, the author decided to code these frames based on deductive coding (i.e. a predefined set of codes or a codebook developed before analyzing the research data). This method is appropriate for detailed coding (Neale, 2016; Azungah, 2018; Elliott, 2018; Skjott Linneberg and Korsgaard, 2019) and is consistent with another research in this field (Gadamus, 2013; Fletcher, 2016; Fernández *et al.*, 2018). In the next step, the author designed a manual coding scheme (Table 1: structure of coding scheme) based on detailed descriptive coding. In this case, Study of Political Graffiti (R, 2019) and Cann and Raymond (2018), whose coding and analysis scheme were used for textual analysis after their classification, can be considered. However, author classification and coding in the present study include new frames – innovative structures – that did not reveal precisely in these studies (Graffiti R, 2019; Cann and Raymond, 2018).

Therefore, the author loaded codes into software such as QDA Miner and Voyant Tool (for understanding the frequency of words and phrases). Voyant Tool is an open-source text-mining option that is user-friendly and well documented (Miller, 2018; Hetenyi *et al.*, 2019).

Classified sections	Central frames	Codes
The general unit of analysis is the Summary for Policymakers (SPM)		
The current state of the climate	A	SPM_a
Possible climate futures	B	SPM_b
Climate information for risk assessment and regional adaptation	C	SPM_c
Limiting future climate change	D	SPM_d

Source: Author

Table 1. Structure of coding scheme

The author of this research has used software – QDA Miner – to remove images and text formatting. According to researchers (i.e. Cuva, 2015; Derobertmasure and Robertson, 2013) QDA Miner is a valuable tool to obtain a corpus and understanding the current state of the scientific investigations.

4. Results

In the results section, the Report SPM (excluding the annexes, the supplementary materials, the final government distribution, etc.) considers to explore the words most used and concepts in all selected codes (Table 1, SPMa, SPMb, SPMc and SPMd). All four sections are taken together by QDA Miner software and systematically exclude authors, images and the format of the text. The word most often used about four selected codes together is global (223). This code revealed that these sections discuss the climate change situation and its global impact. Other words explored in conjunction with "global" were emission, warming climate, change, temperature and high. The analysis identified the word "global" mainly used in terms of global emission and global warming based on selected codes. From the climate economics perspective, there is a discernible link between global emissions and global warming by assuming continued growth in world greenhouse gas emissions (Nordhaus, 2001; Dispensa and Brulle, 2003; Kerr, 2007).

4.1 Codes of classified sections

This subsection looks at how often different codes use different concepts. In contradiction with earlier studies, the author uses a concept-evidence table (e.g. Table 3; SPMa concept-evidence) to support questions and argument(s) and make a clear assessment for this section. Thus, the assessments are based on a number of issues such as the current state of climate, the possible climate future, climate information for risk assessment and regional adaptation, mitigation of future climate change, which helps the author to distinguish between SPMa, SPMb, SPMc and SPMd and to understand the issues in the following sections.

4.1.1 SPMa. The primary goal in this section is to assess the content of the current state of the climate. The analysis by the QDA Miner software (excluding format, images, etc.) and Voyant Tool (frequency of words) revealed 4,695 total words and 997 unique word forms. The most frequent words were (51) confidence, (50) humans, (46) observed, (37) global and (36) changes. To understand more about the relatedness of the words, in this part, the author uses numerical statistics, namely, the TF-IDF (Christian *et al.*, 2016). Therefore, the combined TF-IDF technique is an effective way to identify meaningful technical keywords, make relationships between them and present the central concept of SPMa.

$$\mathrm{Tf} - \mathrm{idf} = \mathrm{tf}\,(\mathrm{t},\ \mathrm{d})\ {}^{*}\mathrm{IDF}\,(\mathrm{t})$$

TF: 51, 50, 46, 37, 36
IDF: 4,695 total words
To make up for SPMa keywords accuracy and relations, TF-IDF is calculated as:

$$\mathrm{IDF} = \log \frac{\mathrm{N}}{\mathrm{dft}}$$

Thus, logarithm TF provides the frequency of word method and concept identification effectiveness. Finally, the crucial terms that had the top TF-IDF log were identified by the author in the SPMa (Table 2).

The author has designed a concept-evidence Table 3 based on the frequency of words to obtain a topical concept. The table lists the central concept that is gradually emerging from the above data analysis.

The concept that the author used can be found in the observed impacts of global climate change on human health (McMichael, 2013; M. Shea, 2015; Hondula *et al.*, 2015). Moreover, the setup used here is slightly reported in the impacts of global climate change on extreme events research (Collins *et al.*, 2007; W. Kundzewicz *et al.*, 2014). In brief, the author considers a linear theme model that contains central frame – A – code based on classified section and mainframe, concept and theme (Figure 1).

The key message is that SPMa puts Mitigation-Based Strategies (MBSs) on GCCPm. The results of this part support the idea in previous research (Woodward *et al.*, 2014; Scott *et al.*, 2015; Bruckner, 2016) that investigation and methods have helped researchers and policymakers to explore costs of mitigation for health, set IPCC mitigation policy (MP) for DE carbonization and assess global renewable energy system for IPCC WGs. Therefore, dynamics such as market-based approaches including carbon taxes, subsidies and cap-and-trade programs which depend on MBSs have implications for the GCCPm progress.

Word	Number of words appeared in section	idf
Confidence	51	Log(4,695/51) = 0.465070711
Humans	50	Log(4,695/50) = 0.462728383
Observed	46	Log(4,695/46) = 0.452865702
Global	37	Log(4,695/37) = 0.427112572
Changes	36	Log(4,695/36) = 0.423871721

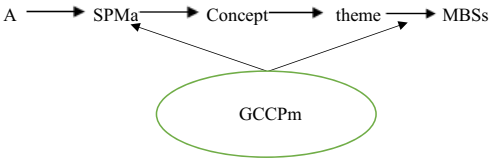
Source: Author

Table 2. Term frequency-inverse document frequency SPMa

Classified sections	Central frames	Codes	Concept
The current state of the climate	A	SPMa	High confidence that humans observed activities globally is the leading cause of the current state of the climate

Source: Author

Table 3. SPMa concept-evidence



Source: Author

Figure 1. SPMa linear model

4.1.2 SPMb. SPMb seeks to address the content of possible climate futures within the IPCC, 2021: SPM. The assessment showed 7,761 total words and 1,154 unique word forms. The use of the terms global 111 (1.86%), warming (1.54) and emissions (1.42) was most frequent in SPMb. The author created a concept-evidence Table 4 by covering the most frequent words such as global, warming and emissions.

Some research was carried out by Taylor and Francis and Elsevier that considered the impacts of global emissions (i.e. greenhouse gas emissions) on the future threat to earth's climate. For instance, investigating the perception of risk of future climate change (Etkin and Ho, 2007) or managing future climate risk (Phelan, 2011). Moreover, articles from Elsevier provided more beneficial insights by samples like the future potential for carbon capture and storage in climate change mitigation (Wennersten *et al.*, 2015), mitigating the anthropogenic global warming (Akorede *et al.*, 2012) and CO_2 emission sources, greenhouse gases and the global warming effect (O.Yoro and O.Daramola, 2020). In a nutshell, the author puts the collection of data – mainframe, code, concept and theme – in a linear model as shown in Figure 2:

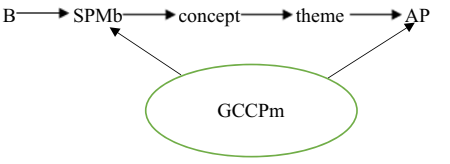
The author identified that the information carried out by possible climate futures linked to Adaptation Policy (AP) which influences GCCPm. The author results do support previous research in this area. For example, the role of the IPCC in decision-making at the local level in the UK has been studied to support adaptation policy at the local level using the interview method (Howarth and Painter, 2016). Furthermore, the statistical downscaling model investigated the AP to improve decision-making capacities for future water demand (Ayt Ougougdal *et al.*, 2020). Thus, the SPMb results have four main implications. From this perspective, the AP plotted to encourage possible future climate change quality such as of water resources, rise in sea level, forests and agriculture that can guide ongoing GCCPm architecture.

4.1.3 SPMc. SPMc aimed to investigate the issue of climate information for risk assessment and regional adaptation in the SPM. This section had 6,868 total words and 772 unique word forms. These words have covered the main concept behind this section of the IPCC report in the Table 6. Most frequent words in the corpus were: box (112) or (2.15%); atlas (110) or (2.11%); confidence (106) (2.00%); regions (88) or(1.66perecent); high (86)or (1.62); global(74) or (1.39); and warming (60) or (1.13) to understand more meaning and the

Classified sections	Central frames	Codes	Concept
Possible climate futures	B	SPMb	Global warming is because of global emissions and is lead to a significant threat to the earth's climate future

Source: Author

Table 4.
SPMb concept-evidence



Source: Author

Figure 2.
SPMb linear model

relatedness of the words. In this part, the author uses practically the TF-IDF technique. Therefore, the combined TF-IDF technique is an effective way to identify meaningful technical keywords, make relationships between them and present the main concept of SPMc in the IPCC SPM report.

$$\mathrm{Tf} - \mathrm{idf} = \mathrm{tf}\,(\mathrm{t},\ \mathrm{d}) * \mathrm{IDF}\,(\mathrm{t})$$

TF: 106, 88,56,74,60
IDF: 6,868

To make up for SPMc keywords accuracy and relations, TF-IDF is calculated as:

$$\mathrm{IDF} = \log \frac{\mathrm{N}}{\mathrm{dft}}$$

Thus, logarithm TF is provided to increase the frequency of words method and concept identification effectiveness.

Finally, the essential terms with the TF-IDF log were identified in the SPMc (Table 5). Concept-evidence Table 6 lists the central concept that is gradually emerging from the above data analysis alongside the evidence that supports those (numbers).

Literature that considers climate risk assessment (e.g. information) for the adaptation often relies on global warming based on regional perspective(s). Some of these studies aimed at providing climate planning and measures (Füssel, 2007; Wilby *et al.*, 2009; Hallegatte, 2009; Conway *et al.*, 2019), while others also conducted more technical analysis (Challinor *et al.*, 2014; Stewart and Deng, 2015). Moreover, some studies concentrate on Africa's climate challenges (Conway and Schipper, 2011; Muller *et al.*, 2011) and others on New Zealand's AP for agriculture (Kenny, 2011). To cut it short, the author assumes a linear theme model (Figure 3).

The author found little empirical evidence of climate information for risk assessment and regional adaptation influencing GCCPm. More recent studies (Torresan *et al.*, 2016; Jenkins *et al.*, 2014; Singh *et al.*, 2020) have been conducted on adaptation strategy for climate change

Word	Number of words appeared in section	idf
confidence	106	Log(6,868/106) = 0.527859122
regions	88	Log(6,868/88) = 0.506794027
High	86	Log(6,868/86) = 0.504191822
global	74	Log(6,868/74) = 0.487181236
Warming	60	Log(6,868/60) = 0.463442769

Source: Author

Table 5. Term frequency-inverse document frequency SPMc

Classified sections	Central frames	Codes	Concept
Climate information for risk assessment and regional adaptation	C	SPMc	Climate risk assessment has high confidence that global warming has an effect on every region and needs adaptation

Source: Author

Table 6. SPMc concept-evidence

risk assessment and management. The policy implication of Adaptation-Based Strategies (ABSs) for climate information, risk assessment and regional adaptation could affect GCCPm by means of strengthening institutional capacity for sustainable development and global health adaptation.

4.1.4 SPMd. To understand SPMd, the author explored the most frequently addressed words in the limiting future climate change section. This corpus has 2,866 total words and 701 unique word forms. Most frequent words were emissions (83); global (42); high (33); warming (31); and confidence (27). To understand the relatedness of the words, the author uses practically the TF-IDF method.

$$\mathrm{Tf} - \mathrm{idf} = \mathrm{tf}\,(\mathrm{t},\ \mathrm{d})\ {}^{*}\mathrm{IDF}(\mathrm{t})$$

TF: 83, 42, 33, 31, 27
IDF: 2,866
To make up for SPMd keywords accuracy and relations, TF-IDF is calculated as:

$$\mathrm{IDF} = \log \frac{\mathrm{N}}{\mathrm{dft}}$$

Thus, logarithm TF shows the frequency of words.

Finally, the author identified (Table 7) the crucial terms that had the top TF-IDF log in the SPMd.

To understand the complexity and meaning of these words, the author developed Table 8 that allows the reader to go through the main concept. The concept-evidence table lists the

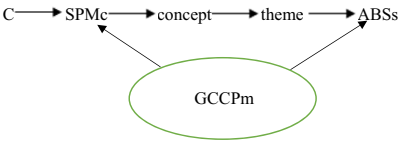


Figure 3.
SPMc linear model

Word	Number of words appeared in section	idf
Emissions	83	Log(2,866/83) = 0.555083826
Global	42	Log(2,866/42) = 0.469516811
High	33	Log(2,866/33) = 0.43922263
Warming	31	Log(2,866/31) = 0.431368978
Confidence	27	Log(2,866/27) = 0.414014874

Source: Author

Table 7.
Term frequency-inverse document frequency SPMd

Classified sections	Central frames	Codes	Concept
Limiting future climate change	D	SPMd	There is high confidence that GHG emissions are the leading causes of global warming

Source: Author

Table 8.
SPMd concept-evidence

central concept which is gradually emerging from the data analysis alongside the numbers (Table 7). To put it another way, the author used the concept-evidence table to gradually assess the quantity and completeness of data is concerning this code (SPMd).

The concept of SPMd was associated with climate management studies (e.g. Prado-Lorenzo, 2009); ecological research (Parmesan *et al.*, 2013); climate change and food security (Crippa *et al.*, 2021); and energy resources (Zhao, 2011).

Thus, to summarize, the author designs a structured theme model for this section of the report as follows (Figure 4):

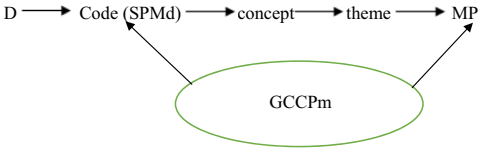
The analysis and results show that what kind of climate mitigation attempts for the future have been taken by SPM to support global policymaking (Beck and Oomen, 2021). On the other hand, Bruckner (2016) investigated future baseline and mitigation scenarios in the IPCC SPM. MP is a critical foundation of global climate change policy making for limiting future climate change. It shapes incentives for future cost-effective reduction of GHGs and provides basis for innovation and sustainable carbon market (i.e. carbon-pricing policy).

5. Discussion

In this article, the author evaluated the content of SPM (IPCC AR6), with the main current global climate change concepts. The author found that concepts tend to concentrate on and discuss the causes of climate change and its effects. As demonstrated in Tables 3, 4, 6 and 8, understanding concepts were dynamics to identify four critical global climatic change themes. This progress in planning article and designing tables (i.e. concept-evidence) aims to contribute to the ever-widening debate around how IPCC AR6 (SPM) is responding to the GCCPm (McMahon *et al.*, 2015; Boykoff and Pearman, 2019). Recently, adaptation and mitigation strategies have received significant global attention from many scholars (Bigger and Millington, 2019; Mees *et al.*, 2013; Dhillon and von Wuehlisch, 2013). On the contrary, the author results suggest that identified concepts are engaging with MBSs, MP, AP and ABSs. These results are generally consistent with both the academic arena and climate policy science.

Mitigation addresses the causes of climate change (e.g. accumulation of greenhouse gases in the atmosphere). Thus, regarding SPMa, this research concluded that MBSs were the most prominent theme in the current state of the climate section of the IPCC AR6 report. To clarify, the influence of humans as a cause of atmosphere, ocean and land warming are frequently used by the author for this section. While some authors argued that IPCC's Assessment Report, namely, the WGI Contribution to the Fifth Assessment (AR5) for Policymakers, does not consider particular attention to mitigation strategies (Sachs and Someshwar, 2012; Edenhofer, 2015; Peters *et al.*, 2015), the author argue that SPMa strongly considered MBSs. Another potential explanation may be that IPCC articles are pretty complex, and it may be challenging to understand and present the findings in a single paper.

Based on the results, there are some gaps in our knowledge around IPCC SPM that follow research findings and would benefit from further research, including quantitative evaluation to further examine the method that the author has developed here. Further research might



Sourc: Author

Figure 4.
SPMd linear model

compare, for instance, mitigation strategies with MP in the shift from sections A to D. More methodological work is needed to robustly capture this shift and outcomes of SPM in scientific research. Hence, the author recommends future research to further explore the mitigation strategies in the SPM.

SPMb assessment found that the data gathered in the possible climate futures section were linked to AP. The policy is a principle of action; global warming is the policy area that includes significant uncertainty on future climate change and vulnerabilities. At the same time, the SPM IPCC's AR5 did not include a specific area for possible climate future policy (s). This finding is slightly in line with the previous studies, which have mentioned that the proportion of possible climate futures data on AP in SPM(AR5) is relatively tiny (Lyster, 2017; Owen, 2020).

Because of the article's information and complexity, the author argues that these results yielded convincing evidence in scientific pieces on global environmental politics. Previous research on IPCC's IPCC AR5 SPM has only identified a few case studies about vulnerabilities and AP (Xie *et al.*, 2016; Wardekker and Lorenz, 2019). Other studies pointed out that the IPCC (i.e. SPM) assessment of adaptation strategies received more recognition in AR4 (Klausmeyer and Shaw, 2009; Beck and Mahony, 2017).

The results for SPMc indicated that most data (statistical analysis and information) applied ABSs. This finding extends prior qualitative and quantitative research in the domain of climate change policy and IPCC report for risk assessment and regional adaptation (Beck, 2010; van Aalst *et al.*, 2008; Mach *et al.*, 2016; Djalante, 2019). The author analysis also found that some research investigated IPCC reports for policymakers and risk assessment for adaptation mainly deployed quantitative method(s) (Dessai *et al.*, 2005; Papathoma-Köhle *et al.*, 2016; Terzi *et al.*, 2019). By all means, this study in comparison to other research and scientific articles found new points regardless of SPM (IPCC's Sixth Assessment Report) by a qualitative method. The author argues that the QCA method(s) is beneficial for this purpose (Below *et al.*, 2012; Becker *et al.*, 2013; Poortvliet *et al.*, 2020).

SPMd applied a specific exploratory view which revealed at least 216 different corpus for the limiting future climate change section. The research identified a theme MP which in the past years (2014) has been slightly described by a few scientists applying qualitative method and design (Lewandowsky *et al.*, 2014). On the contrary, on these grounds (s), many studies have used quantitative methods (Taconet *et al.*, 2020; Larson and Portmann, 2019; Rogelj *et al.*, 2013).

6. Conclusion

This article used qualitative data analysis (SCA) to review and study what four sections of the SPM IPCC AR6 WGI have said about climate change, which can potentially influence GCCPm. The author classified the four main sections based on frames A, B, C and D. Then, the author took sections and frames together by a manual coding scheme, namely, SPMa, SPMb, SPMc and SPMd. After that, the author summarized vital codes and highlighted the main concepts. In the next step, the author assessed the critical themes based on the evidence of the AR6 WGI report and concepts analysis presented in Tables 3, 4, 6 and 8.

Throughout 42 pages of SPM, the most compelling evidence of the SPM is that the different codes talk about mitigation and AP and strategies as driving forces for GCCPm. The algorithm to quantify the data and understand relatedness of words improves semantic processing to compare different sections in the report. Consequently, algorithms are expected to enhance and support the reliability of SPM analysis for emerging strategies and policies. The words used in connection to SPMa are confidence and

humans (101 times) and 119 (observed, global and changes). This assessment suggests that the SPM talks about MBSs, for the current state of the climate and actions. In addition to that, SPMd discusses MP for limiting future climate change. Taking together, SPMa and SPMd received low signals of adaptation (i.e. policy and strategy). Whereas mitigation was the main driving force behind the SPMa and SPMd of IPCC AR6 WGI, SPMb and SPMc consider much more adaptation information concerning possible climate futures and climate information for risk assessment and regional adaptation. These sections have much less to say about mitigation strategies and policy. Here is a round-up of the main points of the discussion:

- SPMa · MBS Σ GCCPm = Decision-makers
- SPMb · AP Σ GCCPm = Policymakers
- SPMc · ABS Σ GCCPm = Decision-makers
- SPMd · MP Σ GCCPm = Policymakers

The SPMa (logic symbol ·) and SPMd reflect the concept of MBS and MP on (i.e. Σ) GCCPm for decision-makers and policymakers, respectively. The SPMb and SPMc cover AP and ABS on (Σ) GCCPm for (i.e. =) policymakers and decision-makers.

Therefore: Climate change mitigation in the context of the current state of the climate is an essential solution for GCCPm. The author argues that the main MBSs for GCCPm are negative emissions technologies and techniques (i.e. biogenic-based sequestration techniques), which decision-makers can deploy for better GCCPm. Climate change adaptation in possible climate futures is an essential solution for GCCPm. The author argues that the central AP f or GCCPm is the development of national strategies by policymakers.

Adaptation to climate change in the context of climate information for risk assessment and regional adaptation is an essential solution for GCCPm. The author argues that the importance of climate information for risk assessment and regional adaptation in climate change policymaking is recognized globally by decision-makers through the existing ABSs that attempt to lead to disaster risk reduction regionally. Mitigating climate change in limiting future climate change section is an essential solution for GCCPm. The author argues that the central MP for GCCPm is conventional mitigation policies used by policymakers for decarbonization technologies and techniques that reduce CO_2 emissions, such as renewable energy, fuel switching, efficiency gains, nuclear power and carbon capture storage and use. Engaging MBSs, AP, ABSs and MP in the GCCPm process increases the chance of the IPCC AR6 WGI SPM impact on global climate change governance output.

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Further reading

Masson-Delmotte, V., Zhai, A., Pirani, S., Connors, L., Péan, C., Berge, S., *et al.* (2021), Working Group I Contribution to the IPCC Sixth Assessment Report (AR6), Climate Change 2021: The Physical Science Basis, Cambridge University Press.

Appendix. List of abbreviations

ABSs	= Adaptation-Based Strategies;
AP	= Adaptation policy;
AR6	= Sixth Assessment Report;
CAQDAS	= Computer-assisted qualitative data analysis software;
CRT	= Cross-cutting research themes;
GCCPM	= Global climate change policymaking;
IPCC	= Intergovernmental Panel on Climate Change;
MBSs	= Mitigation-based strategies;
MP	= Mitigation policy;
QCA	= Qualitative content analysis;
SCA	= Summative content analysis;
SDSM	= Statistical downscaling model;
SPM	= Summary for policymakers;
TA	= Thematic analysis;
TF-IDF	= Term frequency-inverse document frequency; and
WGI	= Working Group I.

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