RESOURCES *for the* FUTURE

Exploring the Stakeholder's Perceptions of Solar Geoengineering in Developing Countries

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About the Project

The Resources for the Future Solar Geoengineering research project applies tools from multiple social science research disciplines to better understand the risks, potential benefits, and societal implications of solar geoengineering as a possible approach to help reduce climate risk alongside aggressive and necessary mitigation and adaptation efforts. The project began in 2020 with a series of expert workshops convened under the SRM Trans-Atlantic Dialogue. These meetings resulted in a 2021 article in *Science* that lays out a set of key social science research questions associated with solar geoengineering research and potential deployment. The Project followed this with additional sponsored research, including a competitive solicitation designed to address research areas highlighted in the Science article. This paper is one of eight research papers resulting from that competition and supported by two author workshops. A key goal of the solicitation and the overall project is to engage with a broader set of researchers from around the globe, a growing number of interested stakeholders, and the public.

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Sharing Our Work

Abstract

The idea of solar geoengineering (SG) remains an elusive one, particularly in several of those developing countries that are most affected by climate change (CC). This knowledge gap can be addressed by identifying the perception of CC and then introducing and soliciting feedback on SG from a select group of developing countries. Building upon an earlier attempt to achieve these aims, a new group of three developing countries in the Global South (Pakistan, Nigeria, and Kenya) was selected to examine their perspective via more than 1,000 responses. Descriptive and inferential results indicate significant differences within the Global South on awareness of CC, SG, and deployment of sulfate aerosols as a measure to delay the harshest effects of CC.

Contents

1. Introduction

Long-term climate change (CC) targets were established by the 2015 Paris Agreement, which called for keeping the rise in global temperatures well below 2.0°C and ideally below 1.5°C compared to preindustrial levels (Sugiyama et al. 2020). Nevertheless, the global community is still struggling to accomplish these lofty goals. Because the current level of mitigation effort is deemed insufficient, some experts advocate for more extreme strategies, such as climate engineering (CE) or solar geoengineering (SG), which refers to a broad category of direct manipulations in the global climate system to combat global warming (NRC 2015a, b; UNEP 2018; Aldy et al. 2021; Dai et al. 2021; Táíwò and Talati 2021; Schubert 2022).

One class of SG, solar radiation management/modification (SRM), has been suggested as a means of keeping the temperature increase below the 1.5–2°C barrier (MacMartin et al. 2018; Sugiyama et al. 2018). SRM refers to a group of as-yet-unrealized technologies that aim to reflect some sunlight back and thus reduce climate impact. Some scientists and policymakers have been paying more attention to stratospheric aerosol injection (SAI), releasing aerosol particles into the stratosphere to simulate the cooling effect of volcanic eruptions.

SAI is not a replacement for reducing greenhouse gas (GHG) emissions, but it might serve as a temporary strategy to contain warming and serve as a stopgap measure, giving humanity more time to mitigate GHG emissions and adapt to a changing climate. SAI is being investigated for its potential as a stopgap measure against CC (NASEM 2021).

Some of the effects of CC appear to be avoidable with SAI (Irvine et al. 2019). According to climate models, it can bring local, regional, and global temperatures and precipitation closer to preindustrial levels. The main benefits are its quick deployment, quick activation, and the reversibility of its direct climatic impacts. Although still out of reach for individuals, small states, or other nonstate actors, SAI appears technically feasible and cheap in terms of direct financial costs; however, it would be the exclusive domain of powerful, national economies or coalitions that include at least one such economy (Smith 2020).

SAI does not solve ocean acidification because it does not directly lower carbon dioxide (CO_2) levels in the atmosphere. Use of SAI that is excessive, inadequately dispersed, or abruptly terminated could have detrimental effects on the environment. As little research has been done, other detrimental effects are possible, but uncertainty remains high as well. Several factors make regulating SAI difficult, including the likelihood that few nations could handle it on their own (Parson and Reynolds 2021; Wagner 2021).

The Geoengineering Model Intercomparison Project (Geo-MIP) is a climate modeling study that has significantly advanced scientific knowledge of the possible benefits and dangers of SAI approaches (Kravitz et al. 2013; NRC 2015b). Many uncertainties remain about the social and environmental hazards of such extensive, technical interventions (Sugiyama et al. 2020). It is generally agreed that a thorough societal discussion about regulation would be necessary, given the high stakes for humanity and high level of uncertainty (Carr et al. 2013, 2018).

Some early research initiatives specifically incorporated public involvement activities within their study programs (Pidgeon et al. 2013; Sugiyama et al. 2017; Olanrewaju et al. 2018; Delina 2021). SAI, according to Sugiyama et al. (2020), is a contentious idea. The governance of SAI is viewed as needing an open and worldwide discussion due to significant concerns regarding the global effects of deployment. Up until now, the majority of public perception studies on SAI have only focused on the Global North or Western democracies. Such research must also take into account the opinions of the Global South, to overcome any Global North bias, as societal acceptability is essential for SAI governance. More social science studies examining public perceptions of SAI are needed to encourage public discourse on the subject. Global South countries, such as Pakistan (Malik et al. 2012; Waheed et al. 2021), Kenya (M'mboroki et al. 2018; Koech et al. 2020), and Nigeria (Adejuwon 2013), are highly vulnerable to CC.

Hence, this present study explores the attitudes toward SAI in developing countries (Pakistan, Nigeria, and Kenya) by surveying online more than 1,000 stakeholders, including university faculty members and students. Our goal is to close this research gap on SAI perceptions by extending its geographical and socioeconomic focus beyond the Global North and previously studied Global South areas.

2. Methodology

2.1. Survey Instrument

Our survey was based on earlier surveys of the public's opinions on SAI (Sugiyama et al. 2020). Views toward SAI field tests were the main focus because the discussion of SRM governance at the moment is more concerned with research, particularly outdoor field tests, than with deployment (NRC 2015b).

We added several questions focusing on opinions about SAI field testing to closely align public perception research with the ongoing governance debate in these developing countries.

2.2. Sample

Eight hundred questionnaires were disseminated among stakeholders in Kenya, 1,200 in Nigeria, and 900 in Pakistan; 362 respondents filled out surveys from Kenya and 353 each from Nigeria and Pakistan, respectively. This indicates a response rate of 30 percent for Kenya, 29 percent for Nigeria, and 39 percent for Pakistan. After data cleaning, the overall sample size for each country is 345 for further analysis.

Respondents of Kenya, Nigeria, and Pakistan were 66 (34) percent, 45 (55) percent, and 65 (35) percent male (female), respectively. Kenya had 1 percent transgender respondents. The response rate of faculty was 50, 68, and 40 percent from Kenya, Nigeria, and Pakistan, respectively. The response rate of students was 43, 30, and 58

percent from Kenya, Nigeria, and Pakistan, respectively. The government policymaker response rate was 7, 1, and 3 percent from Kenya, Nigeria, and Pakistan, respectively. In Kenya, the subject specialization of respondents was in natural sciences (64 percent), social sciences (22 percent), and humanities (13 percent). A high proportion of natural science specialization was also seen in Nigeria (83 percent) and Pakistan (58 percent), followed by humanities (10 and 21 percent, respectively) and social sciences (7 and 20 percent, respectively).

2.3. Data Cleaning and Preprocessing

An initial data review was carried out to ensure that questionnaires were properly filled out, and we removed any invalid responses: 17 from Kenya and 8 each from Nigeria and Pakistan. Furthermore, to make an equal sample size for all three countries, the extra Kenyan questionnaires were removed as preanalysis data processing. Some respondents also mentioned their city name to reply to the "Your country" basic information question. For homogeneity, we replaced city names with the appropriate country name. For example, some respondents listed Swat and Islamabad, and we replaced those with "Pakistan."

3. Results and Discussion

3.1. Concerns Over Global Warming

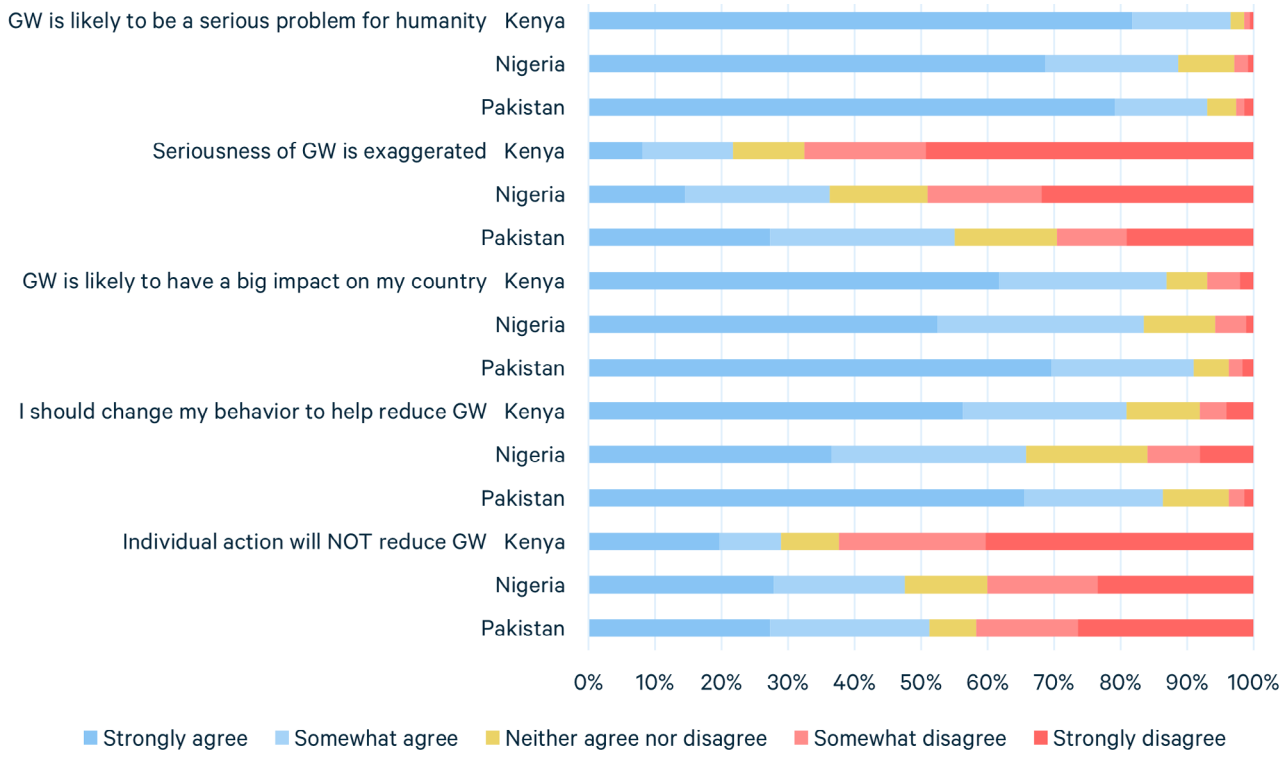
The respondents of all three countries (95 percent) had fairly high confidence that human-caused CC was occurring (Q1); More than 84 percent of respondents, i.e., 91 percent from Kenya, 82 percent from Pakistan, and 79 percent from Nigeria, respectively believed that it is due to anthropogenic activities (Q2). The vast majority (Kenya: 80 percent, Pakistan: 77 percent, and Nigeria: 61 percent) agreed that "most scientists think GW [global warming] is happening," with a minority (Nigeria: 27 percent, Kenya: 15 percent, and Pakistan: 12 percent) agreeing that "there is a lot of disagreement among scientist over whether GW is happening or not" (Q3).

For CC concerns (Q4), 89, 86, and 69 percent in Pakistan, Kenya, and Nigeria, respectively, selected the option "very worried" or "somewhat worried"; this was higher than the reverse options ("not very worried" or "not worried at all"), indicating fairly high concerns. However, for Nigeria, 27 percent of respondents were "not very worried" about CC, almost three times as many as Kenya (11 percent) and Pakistan (9 percent). There is also a high degree of awareness of CC impacts on Global South countries at the personal level (Q5): 49, 32, and 21 percent of respondents from Pakistan, Kenya, and Nigeria, respectively, felt that it was personally "extremely important," followed by "very important" (33, 41, and 37 percent from Pakistan, Kenya, and Nigeria, respectively). In terms of solutions (Q6), respondents were mostly in favor of large-scale interventions, even if they have large consequences (Kenya: 58 percent, Pakistan: 54 percent, and Nigeria: 52 percent), followed by medium-scale interventions, even if they have medium consequences (Kenya: 35 percent, Pakistan: 30 percent, and Nigeria: 39 percent).

Furthermore, 82 percent of respondents from Nigeria, 79 percent from Kenya, and 69 percent from Pakistan, respectively, "strongly agreed" that CC would pose a thoughtful threat to humanity (Q7S1). When asked if "the seriousness of GW was exaggerated" (Q7S2), 49 percent of Kenyan respondents "strongly disagreed," compared to only 32 and 19 percent of Nigerian and Pakistani respondents, respectively; 55 percent of Pakistani respondents "strongly agreed" or "somewhat agreed," compared to only 36 and 22 percent of Nigerian and Kenyan respondents, respectively. The majority of respondents in Pakistan (70 percent), Kenya (62 percent), and Nigeria (52 percent) "strongly agreed" that "GW would have a big impact on their country"; fewer respondents "strongly agreed" and "somewhat agreed" in Nigeria (36 percent) and Pakistan (55 percent) (Q7S3). A large portion of Nigerian respondents (32 percent) "strongly disagreed."

To combat CC, the majority of respondents from all countries "strongly agree" (Kenya: 56 percent, Nigeria: 52 percent, and Pakistan: 70 percent) and "somewhat agree " with behavioral changes (Q7S4). This result indicates that Global South countries are cognizant of the impacts on their countries and personal property and willing to take action to mitigate GW. Global South countries also have a high awareness that CC will likely not be solved due to individual action (Q7S5); 51 percent of Pakistani, 48 percent Nigerian, and 29 percent of Kenyan respondents, respectively, "strongly agreed" or "somewhat agreed." However, a large proportion (42 from Pakistan; 40 percent from Nigeria; and 62 percent from Kenya) "strongly disagreed" or "somewhat disagree." This indicates a high level of diversity of opinion on appropriate solutions. Figure 1 presents the results for Q7.

Figure 1. Respondents' feelings regarding GW for Kenya, Nigeria, and Pakistan

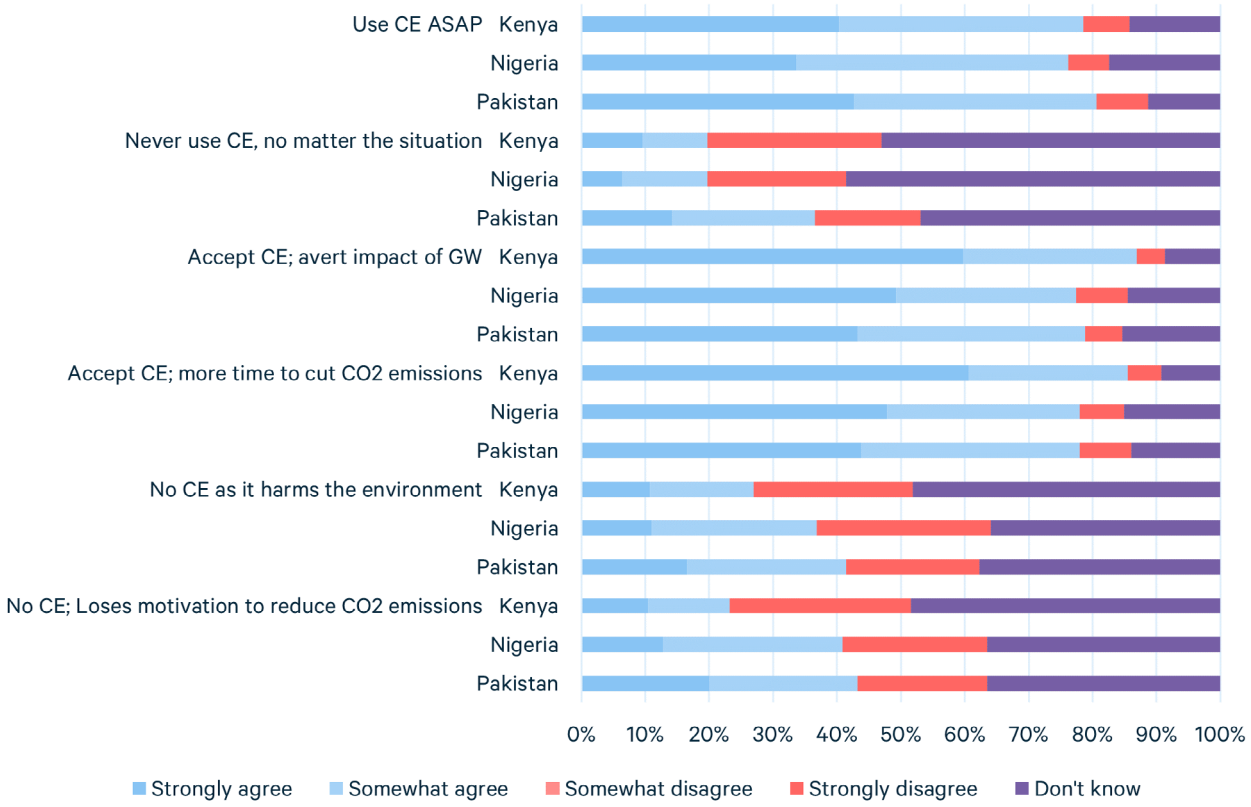


3.2. Support for CE Research

Self-reported knowledge on CE was found to be divisive—with a majority of Kenyan (36 percent) and Pakistani (34 percent) but only 28 percent of Nigerian respondents reporting that they "have heard of and know little about" CE. The majority (35 percent) of Nigerian respondents reported having "never heard of nor know about CE at all" (Q8). A minority reported having "heard of and knowing a lot about CE": Pakistan (21 percent), Kenya (12 percent), and Nigeria (10 percent). In the context of affective feelings about CE (Q9), a strong majority of respondents from all countries felt "very positive" (Pakistan: 41 percent, Kenya: 41 percent, and Nigeria: 33 percent) and "fairly positive" (Nigeria: 40 percent, Pakistan: 38 percent, and Kenya: 37 percent).

Respondents were asked to rate their level of agreement on various aspects of CE use statements. The majority "strongly agreed" and "somewhat agreed" that it should be used as soon as possible (Q10S1): 81, 79, and 76 percent from Pakistan, Kenya, and Nigeria, respectively. When the reverse statement was posed—"CE should never be used, no matter the situation" (Q10S2)—the majority from all three countries selected the "Don't know" option (Nigeria: 59 percent, Kenya: 53 percent, and Pakistan: 47 percent). A high degree of agreement also existed regarding the "willingness to allow CE, if it averts the worst consequences of GW" and "if it gives more time to reduce GHG emissions" (Q10S3 and Q10S4). Kenyan respondents "strongly agreed" at 60 and 61 percent, respectively, followed by Nigerian respondents (49 and 48 percent), and Pakistani respondents (43 and 44 percent). Respondents were also asked about when not to use CE, "if it causes harm to the environment" and "if it reduces people's motivation to reduce CO_2 emissions" (Q10S5 and Q10S6). In both situations, the majority from all countries selected the "Don't know" option: Kenya (48 percent for both); Pakistan (38 and 37 percent, respectively); and Nigeria (36 and 37 percent, respectively). Those who did answer were fairly well captured by the "strongly agree," "somewhat agree" and "strongly disagree" categories in all three countries. Figure 2 presents the results for Q10.

Figure 2. Respondents' feelings regarding use of CE for Kenya, Nigeria, and Pakistan



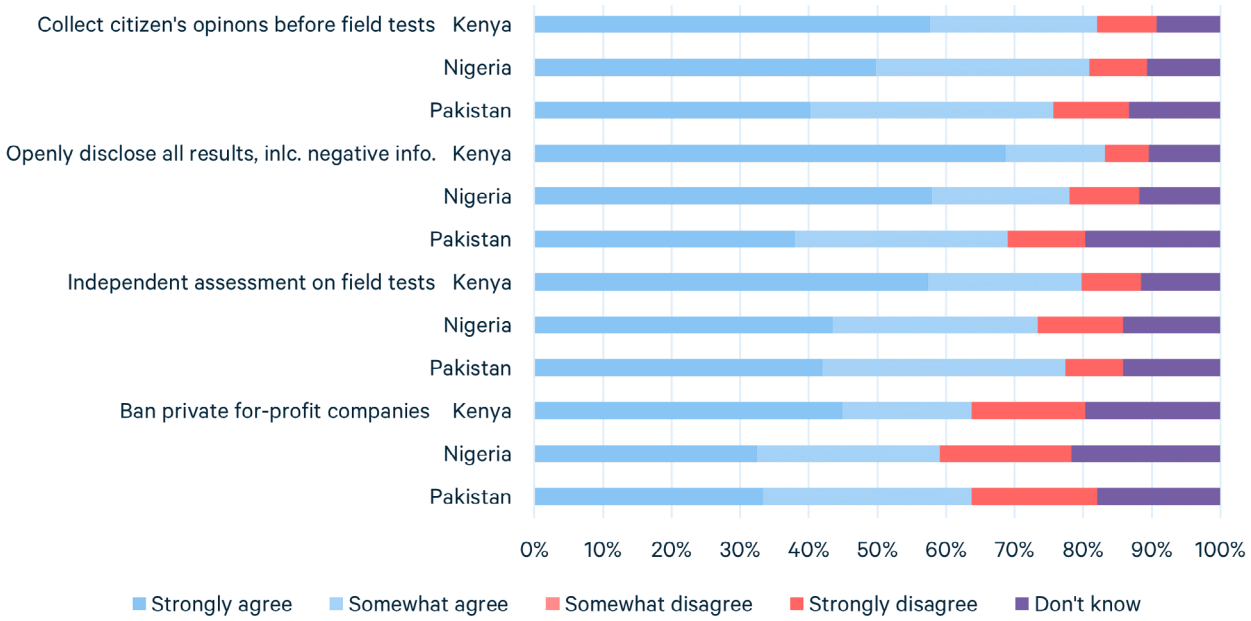
3.3. Consensual Demand for CE Research Governance

As for CE field testing (Q11), the majority of respondents were "willing to accept" that scientists will conduct field tests (Kenya: 56 percent; Pakistan: 51 percent; and Nigeria: 44 percent), and some were "reluctant, but willing to accept CE needs to combat GW" (Nigeria: 34 percent, Pakistan: 23 percent, and Kenya 21 percent). Similarly, respondents were most in favor of "an international framework" for regulating CE (Q12) (Kenya: 60 percent, Pakistan: 54 percent, and Nigeria: 51 percent), followed by "national-level regulation" (Nigeria: 25 percent, Pakistan: 23 percent, and Kenya: 21 percent).

Questions related to CE disclosures had a high level of agreement among all countries. The vast majority either "strongly agreed" or "somewhat agreed" that "scientists should listen to public opinion prior to conducting CE field tests" (Q13S1): Kenya (82 percent), Nigeria (81 percent), and Pakistan (76 percent). Similar levels of agreement were found for the statement "scientists should openly disclose all results, including negative information" (Q13S2): Kenya (83 percent), (78 percent), and Pakistan (69 percent). When asked about independent assessments on how to conduct CE field tests" (Q13S3), Kenyan (80 percent), Pakistani (77 percent), and Nigerian (73 percent) respondents "agreed" that these should occur. Agreement was lower that "private-for-

profit companies should be banned from CE activities" (Q13S4): Kenya (64 percent), Pakistan (64 percent) and Nigeria (59 percent). These results indicate that Global South countries are aware of the role regulation must play in managing CE, including roles for disclosure and private companies in the future. Figure 3 presents the results.

Figure 3. Respondents' opinions regarding CE disclosures for Kenya, Nigeria, and Pakistan



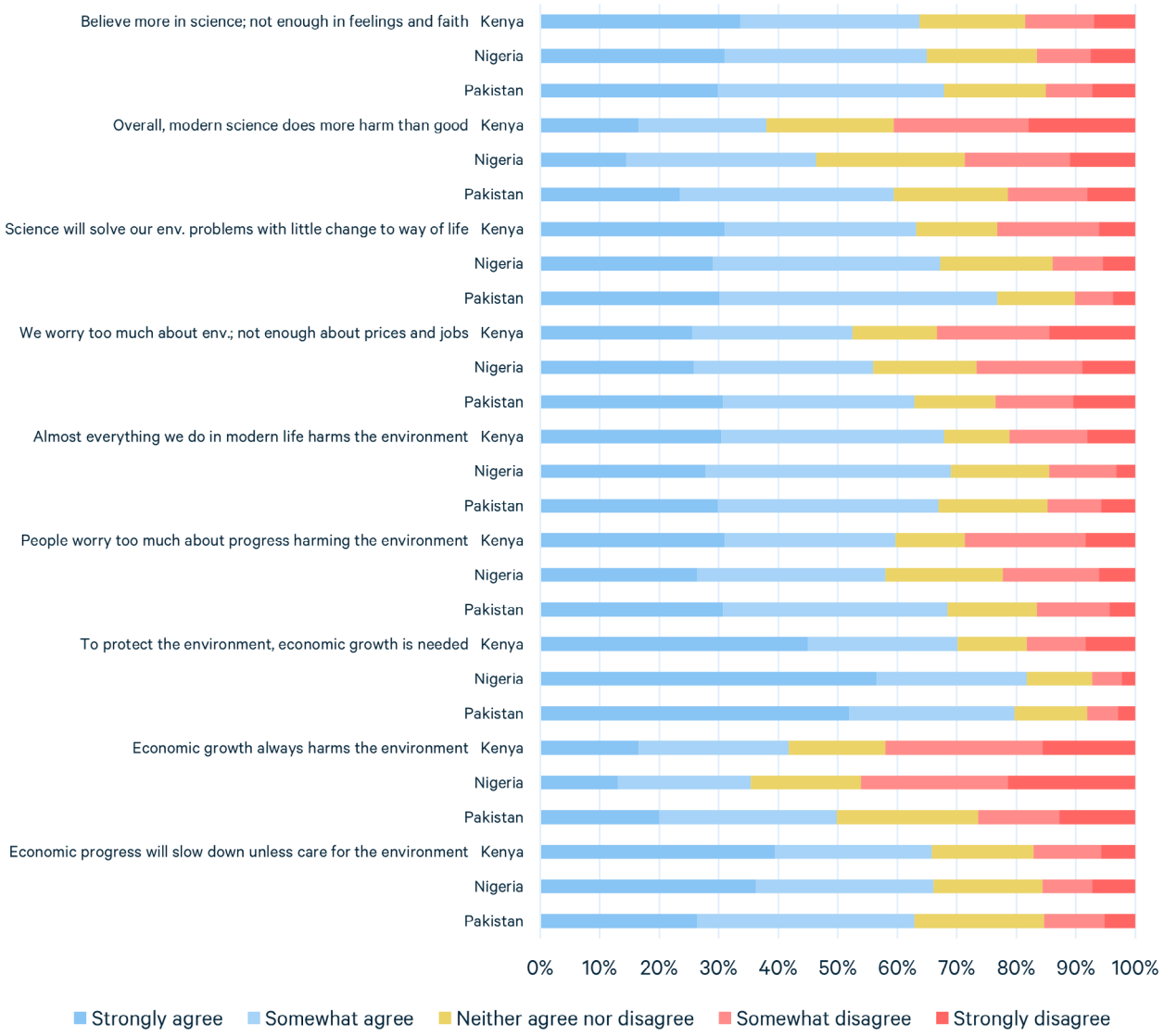
Considering which countries should take the leading role in CE research, including the field test (Q14), the majority of respondents of all countries said that the countries with "high technical capacity" should take initiative in Kenya: 41 percent, Nigeria: 40 percent, and Pakistan: 34 percent, whereas the response for the option "largest CO_2 emissions" should take the initiative was as follows: Kenya: 35 percent, Pakistan: 33 percent, and Nigeria: 29 percent. Out of the government policymakers, the majority selected the option "largest CO_2 emissions" (Kenya: 38 percent, Nigeria: 60 percent, and Pakistan: 44 percent), followed by "high technical capacity" countries (Kenya: 38 percent, Nigeria: 20 percent, and Pakistan: 22 percent).

Similarly, most respondents from Kenya (45 percent), Pakistan (39 percent), and Nigeria (32 percent) "strongly supported" the proposal of CE to combat GW (Q15). A considerable number of respondents (Nigeria: 45 percent, Kenya: 39 percent, and Pakistan: 39 percent) "tend to oppose" it. These results indicate that knowledge and views of CE are a divisive issue in the Global South.

3.4. Views on Environment, Society, Science, and Trust in Institutions

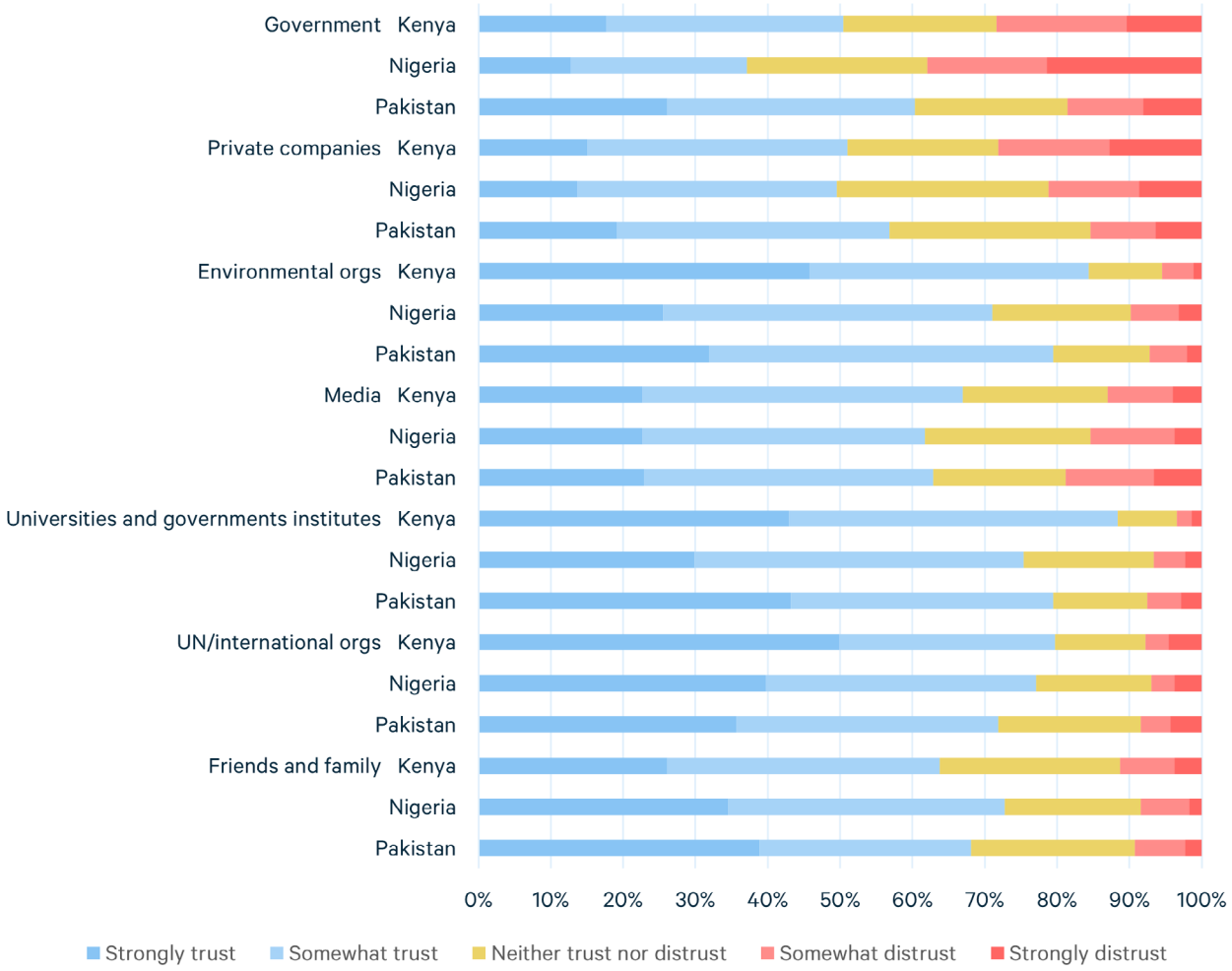
Additional questions asked about the view of the environment, society, science, and trust in institutions. Of the three questions related to science, agreement was highest among all three countries that science was believed in more often than feelings and religion (Q16S1) (Pakistan: 68 percent, Nigeria: 65 percent, and Kenya: 64 percent), with lower levels of agreement that modern science does more harm than good (Q16S2) (Pakistan: 59 percent, Nigeria: 46 percent, and Kenya 38 percent). When asked if "modern science will solve our environmental problems with little change to the way of life" (Q16S3), respondents tended to agree—Pakistan: 77 percent, Nigeria: 67 percent, and Kenya 63 percent. The linkage between economic growth and environmental protection was also tested, and respondents agreed that "almost everything we do in modern life harms the environment" (Q16S5): Nigeria: 68 percent and Pakistan and Kenya: 67 percent each. Higher agreement was found for the statement "to protect the environment, economic growth is needed" (Q16S7): Nigeria: 82 percent, Pakistan: 80 percent, and Kenya: 68 percent. When the reverse was asked, "economic growth always harms the environment" (Q16S8), respondents agreed less—Pakistan: 50 percent, Kenya: 42 percent, and Nigeria: 35 percent. Figure 4 presents the results.

Figure 4. Respondents' views on science, environment, and economy for Kenya, Nigeria, and Pakistan



In terms of trust in institutions, government (Q17S1) and private companies (Q17S2) scored lowest for all countries. Pakistan (60 percent) had higher trust in government, compared to Kenya (50 percent) and Nigeria (37 percent). Private companies were similar (Pakistan: 57 percent, Kenya: 51 percent, and Nigeria: 50 percent). Environmental organizations (Q17S3), researchers at universities and institutions (Q17S6), and NGOs/international organizations (Q17S7) received the highest agreement: Kenya: 84, 88, and 80 percent, respectively; Pakistan: 79, 79, and 72 percent, respectively; and Nigeria: 71, 75, and 77 percent, respectively. The media and friends and family also scored similarly. The results are presented in Figure 5.

Figure 5. Respondents' level of trust in various organizations for Kenya, Nigeria, and Pakistan



To test the differences between faculty, government policymakers, and students, we performed a Kruskal-Wallis Test nonparametric ANOVA (Sugiyama et al. 2020). Table 1 displays the results. Several statistically significant differences appeared regarding feelings about CE between the faculties of all countries. For Q10S2, Pakistani faculty were more likely to "somewhat agree" that CE should not be used, no matter what, compared to their Kenyan and Nigerian counterparts. Pakistani faculty were also more likely to "disagree" about their willingness to accept the use of CE to avert the most adverse effects of CC (Q10S3), and Kenyan and Nigerian faculty "strongly disagreed." Kenyan faculty were more likely to "strongly agree" to accept the use of CE to delay CO_2 emissions mitigation (Q10S4), whereas Nigerian and Pakistani faculty only "somewhat agreed."

Table 1. Results of the Kruskal-Wallis Test (nonparametric one-way ANOVA) for faculty, government policymakers, and students of Kenya, Nigeria, and Pakistan

Table 1A. Faculty

Country	Q10S1	Q10S2	Q10S3	Q10S4	Q10S5	Q10S6	
Kenya	273.85	285.48	248.57	243.84	304.03	313.80	
Nigeria	282.07	288.86	271.71	273.72	265.47	259.84	
Pakistan	252.41	226.25	301.75	304.20	243.22	240.68	
H-statistic	3.58	18.84***	10.46***	13.26***	13.46***	20.87***	
	Q13S1	**Q13S2**	**Q13S3**	**Q13S4**			
Kenya	255.00	243.45	258.48	260.41			
Nigeria	268.71	262.67	283.15	288,10			
Pakistan	298.87	323.63	269.75	258.95			
H-statistic	7.18***	26.10***	2.85	4.74			
	Q17S1	**Q17S2**	**Q17S3**	**Q17S4**	**Q175S**	**Q17S6**	**Q17S7**
Kenya	267.03	282.76	231.90	261.73	245.68	296.01	296.01
Nigeria	303.10	281.83	299.43	278.20	294.45	265.63	265.63
Pakistan	224.85	241.71	274.99	274.19	266.35	252.95	252.95
H-statistic	22.87***	7.37***	21.05***	1.24	11.33***	7.09***	7.09***

Note: Statistically significant results are starred.

Table 1B. Government

Country	Q10S1	Q10S2	Q10S3	Q10S4	Q10S5	Q10S6	
Kenya	15.75	19.71	17.54	18.40	21.13	21.25	
Nigeria	28.80	21.00	17.70	14.50	21.80	20.00	
Pakistan	24.33	18.11	25.72	25.22	13.89	14.56	
H-statistic	9.86***	0.31	6.18***	6.08***	3.33	2.69	
	Q13S1	**Q13S2**	**Q13S3**	**Q13S4**			
Kenya	18.15	17.38	19.75	17.88			
Nigeria	15.60	20.70	14.00	22.30			
Pakistan	25.28	24.50	21.89	22.28			
H-statistic	4.60	4.12	2.62	1.66			
	Q17S1	**Q17S2**	**Q17S3**	**Q17S4**	**Q175S**	**Q17S6**	**Q17S7**
Kenya	18.52	20.60	16.73	17.75	17.33	16.81	19.63
Nigeria	25.70	20.60	25.90	26.90	21.90	27.00	21.20
Pakistan	18.67	15.94	23.33	20.06	23.94	22.50	18.22
H-statistic	2.04	1.27	5.08	3.10	3.03	5.70	0.26

Note: Statistically significant results are starred.

Table 1C. Students

Country	Q10S1	Q10S2	Q10S3	Q10S4	Q10S5	Q10S6	
Kenya	229.53	226.02	204.28	205.85	244.98	247.51	
Nigeria	245.10	247.37	250.02	248.50	209.78	221.49	
Pakistan	216.68	218.13	233.12	232.74	223.68	215.59	
H-statistic	3.76	4.05	9.60***	8.49***	5.23	5.93	
	Q13S1	**Q13S2**	**Q13S3**	**Q13S4**			
Kenya	206.38	190.43	194.90	214.66			
Nigeria	225.46	219.73	241.85	226.22			
Pakistan	244.49	259.54	244.50	237.85			
H-statistic	8.51***	29.07***	16.06***	2.92			
	Q17S1	**Q17S2**	**Q17S3**	**Q17S4**	**Q175S**	**Q17S6**	**Q17S7**
Kenya	233.78	239.26	206.56	228.29	216.50	215.51	245.95
Nigeria	269.00	226.45	252.38	218.93	258.56	229.24	215.14
Pakistan	200.87	219.19	230.16	231.43	219.40	235.62	220.11
H-statistic	20.31***	2.18	8.87***	0.69	8.94***	2.29	4.96

Note: Statistically significant results are starred.

A statistically significant difference arose in comparing Kenyan faculty against their Nigerian and Pakistani counterparts when asked about not using CE due to its harmful impacts on the environment (Q10S5) or its moral hazard (Q10S6). Half of the Kenyan faculty answered "Don't Know"; only approximately a third of the Nigerian and Pakistani faculty did so. For both questions, Pakistani and Nigerian faculty were almost twice as likely to "strongly or somewhat agree."

With reference to the role the scientific community can play, Pakistani faculty's responses were significantly different regarding how much citizen opinion affect scientific decisions to engage in CE field tests (Q13S1). The same was true for whether scientists should openly disclose field test results, including negative information (Q13S2).

Pakistani faculty displayed a greater level of trust in their government compared to Kenyan and Nigerian faculty (Q17S1). The level of distrust in private companies was higher among Kenyan compared to Nigerian and Pakistani faculty (Q17S2). The level of trust in environmental organization was lowest among Nigerian compared to Kenyan and Pakistani faculty (Q17S3).

Government policymakers had statistically significant differences between countries, with Pakistani officials least likely to suggest use of CE (Q10S1) and most likely to select "Don't Know" when asked their willingness to accept the use of CE to avert the most adverse effects of CC (Q10S3). Pakistani policymakers were also only likely to "somewhat agree" about their willingness to accept the use of CE to buy more time to decrease CO2 emissions, compared to Kenyan and Nigerian policymakers, who "strongly agree."

We performed multinomial logistic regression to analyze and understand what critical factor influenced the attitudes toward SG and CC. Table 2 summarizes the results with the pooled data for Pakistan. Similar data were obtained for Kenya and Nigeria (not shown). We adopted multinomial logistic models because the dependent variables (Q9, Q11, and Q15) are ordinal and we used the middle response as the base. Thus, for Q9 and Q11, the coefficients indicate changes from indifference to support or opposition.

We selected reference category 3 while analyzing the pooled data. The pseudo R2 is not very large, but some statistically significant effects appear, demonstrating that principal components variables related to CC concern (Q5 and Q7); attitudes toward science, environment, and economic growth (Q16), trust in institutions as a source of information about environmental concerns (Q17) identify differing attitudes toward CC. The values for principal components related to Q5 and Q15 were negative for all choices from Kenya respondents (Table S1), and no response was found for choice 2 of Q15 from the Kenya and Nigeria pooled data.

Table 2. Results of Multinominal Logistic Regression of the Pooled Data (Pakistan)

	Q9 (Affective feeling)				Q13 (Support for field testing)				Q15 (Cognitive evaluation)			
	1	2	4	5	1	2	4	5	1	2	4	5
Intercept	5.842	2.993	-5.137	-159.893	3.170	0.282	-5.297	-2.319	7.607	-0.021	4.000	-7.412
Q.5	-0.879	-0.303	-0.080	29.123	0.244	0.532	0.306	0.633	-0.153	0.451	0.291	0.575
Q7S1	-.0480	-0.159	1.001	15.738	0.097	0.359	0.982	0.420	-0.086	0.657	0.147	0.352
Q7S2	-0.294	-.0210	0.397	-31.169	-0.252	-0.268	-1.734	-0.025	-0.005	-0.071	-0.066	-0.155
Q7S3	0.134	0.004	0.397	-12.226	-0.656	-0.255	1.374	-0.426	-0.340	-0.617	-0.109	-0.193
Q7S4	-0.372	-0.181	-0.111	16.373	0.232	0.216	0.067	-0.044	-0.066	0.120	0.423	-0.857
Q7S5	-0.093	-0.078	-0.484	-0.675	0.343	0.275	-0.436	0.212	-0.118	0.239	0.001	-0.846
Q16S1	-0.391	-0.527	-0.651	19.350	0.128	0.258	-0.170	0.614	-0.467	-0.103	-0.267	0.846
Q16S2	0.116	0.353	0.404	-26.527	-0.089	-0.178	-0.108	-0.204	-0.291	-0.337	0.034	0.900
Q16S3	-0.230	0.453	0.271	32.292	-0.097	-0.047	-1.565	-0.020	-0.324	-0.348	-0.168	0.256
Q16S4	0.314	0.149	-0.752	-13.874	-0.095	0.123	0.539	-0.029	0.127	-0.064	-0.072	0.448
Q16S5	0.067	-0.011	-0.882	-11.173	-0.317	-0.329	0.752	-0.408	0.020	0.198	0.089	-0.056
Q16S6	-0.141	-0.025	0.921	-22.710	0.302	0.185	-0.594	0.291	-0.304	0.080	-0.033	0.081
Q16S7	-0.348	-0.317	-0.422	25.279	-0.276	0.151	-0.021	-0.202	-0.277	0.578	-0.153	-0.254
Q16S8	0.053	0.000	-0.670	-25.335	0.262	0.346	0.286	0.385	0.056	0.135	-0.081	0.011
Q16S9	0.120	0.078	1.128	15.116	-0.229	-0.283	0.581	0.026	-0.297	-0.354	-0.241	-0.207
Q17S1	-0.127	-0.127	-0.814	9.843	0.285	-0.039	0.421	0.123	0.291	-0.551	0.276	-0.013
Q17S2	0.247	0.474	0.429	-8.765	-0.223	-0.013	0.281	0.059	-0.218	0.256	-0.086	0.501
Q17S3	-0.128	-0.152	0.654	-26.748	0.264	0.174	0.721	0.285	-0.525	0.294	-0.389	-0.074
Q17S4	-0.166	-0.338	-0.314	5.227	-0.174	-0.212	0.082	-0.258	0.129	-0.260	0.027	0.743
Q17S5	0.286	0.178	-0.669	6.029	-0.252	0.007	0.421	0.017	0.153	-0.898	-0.205	0.775
Q17S6	-0.452	-0.279	0.198	20.614	-0.518	-0.523	0.140	-0.112	-0.468	0.461	-0.471	-0.650
Q17S7	0.040	-0.125	0.629	20.495	0.395	0.246	-0.783	0.133	0.002	-0.329	-0.009	-0.639
N	345				345				345			
Psuedo R^2	0.361				0.306				0.364			

4. Conclusions

The results of this survey indicate a high degree of knowledge about CC and its concerning factors in the studied countries. These results further confirm previous research that Global South countries are likely to accept CE solutions to reduce CC impacts and give more time to decrease CO2 emissions. Developing countries, such as the ones sampled, are highly vulnerable to CC effects and need earlier action to stymy CC impacts, including through CE if climate mitigation strategies do not ramp up at the level required. However, support for CE field testing was found to be low in all countries, with calls for an international framework of regulations to guide research and governance. The countries surveyed also had a high degree of expectation for disclosures from field testing, including negative information.

The survey has some limitations that must be acknowledged. It is an online survey, undertaken across university campuses, and is therefore not a representative sample of developing countries. It is a continuation of previous research attempts to elucidate opinions on the subject, but a nationally representative sample may yield different results. Second, this survey instrument simplified the information regarding CE to a certain extent for ease of respondent's understanding and excluded pertinent information that follow-up surveys may look to incorporate, such as the role of CO2 removal, the concept of a termination shock, and the lack of a response for ocean acidification issues.

Despite these issues, the results still provide some novel insights into the role Global South countries have to play in the coming decades in CE. In particular, the distinctions between the three countries serve to illustrate that the opinions regarding CE in the Global South are varied and divisive. For example, Nigeria tended to regard CC as a lower threat compared to Pakistan and Kenya for two reasons. It is far less vulnerable to CC and one of the largest oil-producing nations in the world. Although calls for CE governance and research are increasing for the Global South, to date the efforts of the scientific community in this arena remain limited. Focusing on all three developing continents, including Central and South America, would also shed greater light on the diversity of opinion present in the Global South.

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