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A Comprehensive Review of Climate Change Impacts on Water Resources: A Global perspective

Sajid Ullah[*1], Muhammad Noman[2], Matiullah Rahimi[3], Abdul Ghani Stanikzai[3], Saima Ayub[4], Zia Ud Din[4], Hamidova Emiliya[5], Sadia Esmati[6], Farhan Zahoor[7], Shehryar Khan[7]

[1]*(School of Resources and Environmental Engineering, East China University of Science and Technology, Shanghai 200237, China)*
[2]*(College of Environmental Science and Engineering, Donghua University, Shanghai 201620, China)*
[3]*(Department of Environmental Sciences, International Islamic University Islamabad 44000, Pakistan)*
[4]*(Department of Environmental Sciences, Abdul Wali Khan University, Mardan 23200, Pakistan)*
[5]*(Landscape-Azerbaijan State Pedagogical University, Baku AZ1000, Azerbaijan)*
[6]*(Department of Natural Resources Management, Faculty of Environmental Science, Kabul University, Kabul 1006, Afghanistan)*
[7]*(School of Environmental Sciences & Engineering, Northeast Normal University, Changchun, 130024, China)*
Corresponding Author: Sajid Ullah (Sajidjalwan@gmail.com)

Abstract
Global climate change has actual severed impacts on world water resources. Numerous hydrological parameters and characteristics of the water resources systems may be influenced by global climate change. The Intergovernmental Panel on Climate Change (IPCC)estimations a global rise of average annual temperature of 0.8°C to 2.6°C by 2050 and it is expected that, with global warming, global mean sea levels may rise by between 7 and 36 cm by the 2050s, The water cycle will be intensified rapidly, with more evaporation and more precipitation and by 2025, it is predicted that around 5 billion people, out of a total population of around 8 billion will be living in countries experience water stress so finally the world will become a water stress planet in the universe. The current paper shows a review of impacts of climate change on water resources.
***Key Word**: Climate change, Water resources, Hydrological cycle, Sea level rise, IPCC*

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I. Introduction

Water is used for human consumption, industrial purposes, irrigation, power production, navigation, recreation and waste disposal, as well as for the maintenance of healthy aquatic ecosystems. In recent years, and particularly since the outcome of the second and third assessment reports of the Intergovernmental Panel on Climate Change (IPCC, 1996) and (IPCC, 2001), it has become clear that global climate change is a scientific reality. An increasing awareness that global climate change will affect water resources has also clearly emerged and this has been reflected in a rapidly growing body of scientific literature. Several hydrological variables and characteristics of the water resources systems may be affected by global climate change.

Also, the gradual increase in drought and human population has made water become a scarce resource not only in arid and drought-prone areas but also in humid or sub-humid zones, leaving its sustainability to be threatened by various human activities (WWF, 2006).It is predicted that, with global warming, global average sea levels may rise by between 7 and 36 cm by the 2050s, by between 9 and 69 cm by the 2080s and 30–80 cm by 2100. The majority of this change will occur due to the expansion of the warmer ocean water (Reshmidevi, et al., 2018). The IPCC Third Assessment Report (IPCC, 2001) estimates a global increase of mean annual temperature of 0.8°C to 2.6°C by 2050 and 1.4°C to 5.8°C by 2100. The study also reports results that indicate an increase in annual precipitation induced by climate change in high and mid-latitudes and most equatorial regions, as well as a general decrease in the subtropics.

Results also show that flood magnitude and frequency is likely to increase, due to the concentration of precipitation in winter in most areas of the globe. Simultaneously, the decrease of low flows in many regions associated with higher temperatures constitutes a serious threat to the quality of water resources.

II. Brief Review of Literature

1. Climate change impacts:

Global warming, due to the enhanced greenhouse effect, is likely to have significant effects on the hydrological cycle (IPCC, 2001). The hydrological cycle will be intensified, with more evaporation and more precipitation, but the extra precipitation will be unequally distributed around the globe. Some parts of the world may see significant reductions in precipitation, or major alterations in the timing of wet and dry seasons.

The Second Assessment Report of the (IPCC) warned that global warming would lead to increases in both floods and droughts. Arshad et al., (2017) claimed a 4% increase in global total runoff per 1°C rise in temperature during the 20th century. The IPCC AR4 projections suggest an increase in global average precipitation, but a decrease in precipitation and thus annual water supply is expected in most regions where the relation of water supply to water demand is already critical today (Ahmed et al., 2013). Most communities and species in freshwater ecosystems are coldblooded and will therefore be sensitive to changes in the water temperature regime (Rosen and Guenther, 2015). It estimated that approximately one-third of the world's population currently lives in countries experiencing moderate to high water stress, and forecast that by 2025 as much as two-thirds of a much larger world population could be under stress conditions simply due to the rise in population and water use (WMO, 1997). While creating awareness among different stakeholders dealing with water use and management in these areas becomes important, further detailed study is necessary to provide quantitative information that would support and provide a framework upon which water could be used and managed. Considering the inadequate of this information and understanding of the effect of climate change on water resources This paper show an overview of impact of climate change on some water variables including temperature, Sea Level Rise , disturbance in hydrological cycle water demand or uses.

2. Temperature:

There is good evidence that as a result of ever increasing atmospheric carbon dioxide (CO_2) and other greenhouse gas emissions from human activity, as well as natural climate variability, the Earth's surface has warmed by over 1.3 °F (0.7° Celsius) during the past century.

These increased temperatures have contributed to an overall rise in sea level. Continued greenhouse gas emissions at or above current rates are expected to cause further warming and induce many changes in the global climate system during the 21st century that will very likely be larger than those observed during the 20th century (IPCC 2007).

Global mean temperatures over land and ocean have increased over the past three decades. The global average surface temperature has risen between 1.08 °F and 1.26 °F since the start of the 20th century (NOAA, 2006).

The rate of increase since 1976 has been approximately three times faster than the century-scale trend. Mean temperatures for the contiguous United States have risen at a rate near 0.6 °F per decade. Six of the ten warmest years on record for the contiguous United States have occurred since 1998 (NCDC, 2008). Including 2007, seven of the eight warmest years on record globally have occurred since 2001 (NCDC, 2008). The 10 warmest years globally have all occurred since 1995 (NCDC, 2008).

The Intergovernmental Panel on Climate Change (IPCC) projects that the average surface temperature of the Earth is likely to increase by 3.2 °F to 7.2 °F (1.8 °C to 4.0 °C) by the end of the 21st century, relative to 19801990 (IPCC, 2007c).

Based on climate models, the area flooded in Bangladesh is projected to increase by at least 23–29% with a global temperature rise of 2°C (Wang et al., 2016).

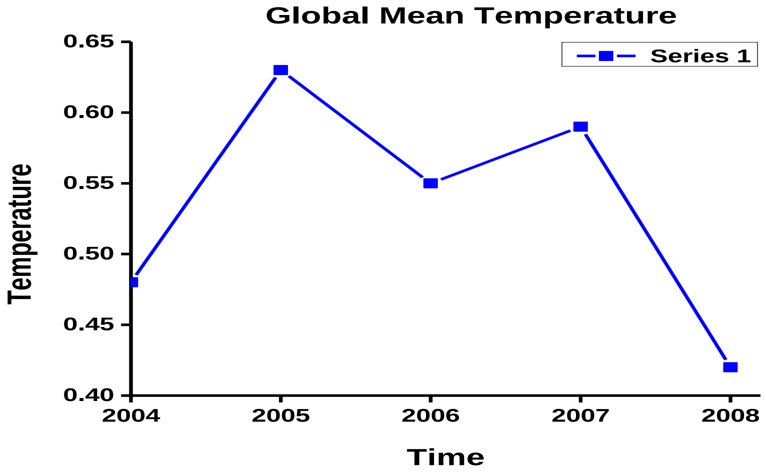

Figure 1: Variations in global mean temperature from 2004-2008.

3. Sea level rise:

The IPCC AR4 Report identifies several major factors that currently contribute to sea level change. These are Ocean thermal expansion' Changes glaciers and icecaps' Glacial melt from the Greenland and Antarctica' Ice Sheets' a smaller contribution from snow on land and permafrost (changes in other Cryosphere components which have marginal impacts)'. Sea level rise (SLR) due to climate change is a serious global threat: The scientific evidence is now overwhelming. The rate of global sea level rise was faster from 1993 to 2003, about 3.1 mm per year, as compared to the average rate of 1.8 mm per year from 1961 to 2003 (IPCC, 2007). It is predicted that, with global warming, global average sea levels may rise by between 7 and 36 cm by the 2050s, by between 9 and 69 cm by the 2080s and 30–80 cm by 2100. The majority of this change will occur due to the expansion of the warmer ocean water (Kling et al., 2012).

Instrumental records reveal that the world's oceans have warmed since 1955, accounting over this period for more than 80% of the changes in the energy content of the Earth's climate system. Records further reveal during the period 1961 to 2003, the 0 to 3000 m ocean layer has absorbed up to 14.1 × 1022 Joules, equivalent to an average heating rate of 0.2 Watts/m2 (per unit area of the Earth's surface). During the 20th century, glaciers and ice caps have experienced widespread mass losses. These losses (excluding those around the ice sheets of Greenland and Antarctica) are estimated to have contributed 0.50 ± 0.18 mm/yr in sea level equivalent (SLE) between 1961 and 2003, and 0.77 ± 0.22 mm/yr between 1991 and 2003. (Yira et al., 2017).

According to the IPCC AR4, it is very likely (> 90% probability) that the Greenland Ice Sheet (GIS) shrunk from 1993 to 2003, with the thickening in central regions being more than offset by increased melting in coastal regions. An assessment of the data suggests a mass balance for the Greenland Ice Sheet of –50 to –100 Gigatons/year (a shrinkage contributing to rising global sea levels of 0.14 to 0.28 mm/yr) from 1993 to 2003, with even larger losses in 2005. The estimated range in mass balance for the GIS from 1961 to 2003 is between a growth of 25 Gt/yr and shrinkage of 60 Gt/yr (or –0.07 to +0.17 mm/yr SLE). The impacts of SLR could be catastrophic for many developing countries. Recent World Bank estimates suggest that even a one meter rise in sea level in coastal countries of the developing world would submerge 194,000 square kilometers of land area, and displace at least 56 million people (Seiller and Anctil, 2014).

4. Disturbance in water cycle:

Human and natural activities affect virtually all sections of the water cycle, often with additive effects. Over time, human activities such as forest clearing, afforestation, agriculture, have disturbing influences on the water cycle including evapotranspiration, flow regimes, groundwater table and sea level. Also, human activities influence cloud formation via the emission of aerosols and their gaseous precursors (Zhang, 2015). There is a general consensus that global average surface air temperature increased during the 20thcentury, and, although there is great uncertainty about the magnitude of future increases, most assessments indicate that future warming is very likely (Fournet et al., 2014; NAST, 2001; ACIA, 2004). There is also a theoretical expectation that climate warming will result in increases in evaporation and precipitation leading to the hypothesis that one of the major consequences will be an intensification (or acceleration) of the water cycle (Esham and Garforth, 2013; Su et al., 2017 and Gbobaniyi et al., 2014). Recent modeling studies suggest that as a consequence of this relation precipitation would increase by about 3.4% per degree Kelvin (Pagan et al., 2016). Results from recent simulations using one of about 20 coupled ocean– atmosphere–land models based on the IS92A mid-range emission scenario indicate that global mean surface air temperature, precipitation, evaporation, and runoff will increase 2.38, 5.2, 5.2, and 7.3%, respectively, by 2050 (Torquebiau, 2013). On a globally averaged basis, precipitation over land increased by about 2% over the period (1900–1998) (Mourato et al., 2015 and Mullan et al., 2012). Regional variations are highly significant. For example, zonally averaged precipitation increased by 7–12%, between 308N and 858N, compared with 2% increases for 08S–558S, and has decreased substantially in some regions (Giorgi et al., 2014 and Simelton et al., 2012). Human activities that increase the atmospheric burden of sulfate, mineral dust, and black carbon aerosols have the potential to affect the water cycle through the suppression of rainfall in polluted areas and through reducing the solar irradiance reaching the earth's surface (Duan et al., 2015 and Eisner et al., 2017).

Table 1: Major trends in both regionally and globally of different parameters due to impacts of climate change.

Variables	20^{th} century	Latter half 20^{th} century	Major trends regional (R) or global (G)
Precipitation	Yes		Increasing (R, G)
Runoff	Yes	Yes	Increasing (R, G)
Tropospheric water vapor		Yes	Increasing (R)
Cloudiness		Yes	No change
Tropical storm frequency & intensity		Yes	No change
Floods	Yes	Yes	Increasing (R)
Droughts		Yes	Increasing (R)
Soil moisture		Yes	Increasing (R)
Seasonal glacier mass balance		Yes	Increasing (R)
Pan evaporation		Yes	Decreasing (R)
Actual evapotranspiration		Yes	Increasing (R)
Growing season length	Yes	Yes	Increasing (R)

5. Water demand:

According to UNEP (2003), about 1,100 million people do not have access to clean drinking water, and contaminated water is the cause of 5 million deaths every year, with the majority of these in sub-Saharan Africa. According to climate model analyses, the number of people at risk due to water scarcity increases rapidly with rising temperatures towards the second half of the century, with impacts in arid and semi-arid regions expected to be much larger than the global averages suggest (IPCC, 2001; Todd, 2011). Thus in regions already under water stress today, including Africa, climate change will exacerbate the situation. For many of the water-distressed regions, global mean temperature increases above 1.5ºC are identified as leading to decreases in water supply and quality (IPCC, 2001). Higher temperatures and increased variability of precipitation would, in general, lead to increased irrigation water demand, even if the total precipitation during the growing season remains the same. The impact of climate change on optimal growing periods, and on yield-maximizing irrigation water use, has been modeled assuming no change in either irrigated area and/or climate variability (Saseendran et al., 2015). The international Dialogue on Water and Climate (2004) noted that water stress will increase significantly in those regions that are already relatively dry (such as sub-Saharan Africa).

Applying the IPCC SRES A2 and B2 scenarios as interpreted by two climate models, it was projected that the net irrigation requirements of China and India, the countries with the largest irrigated areas worldwide, would change by +2% to +15% in the case of China, and by −6% to +5% in the case of India, by 2020, depending on emissions scenarios and climate model (Naseela et al., 2015). By 2025, it is estimated that around 5 billion people, out of a total population of around 8 billion will be living in countries experience water stress (using more than 20% of their available resources). (Tian et al., 2013). This diagram show the data is km3/y.

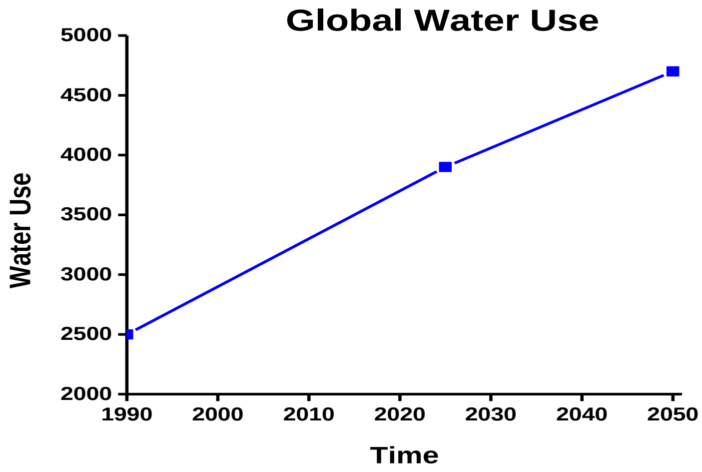

Figure 2: Global water use rapidly increasing worldwide.

6. Overall trend:

Previous and current studies on climate change impacts on water resources shows that the world water resources and other parameters have been greatly affected by climate change. Various parameters such as precipitation, runoff, tropospheric water vapor, cloudiness, soil moisture, floods, droughts, seasonal glacier mass balance, pan evaporation, actual evapotranspiration and growing seasonal length have been greatly affected regionally due to climate change.

Table 2: Overall trends in different parameters estimated by 2050 level.

Variables	Status	2050 level	References
Precipitation	Increasing	5.2 %	(Wetherald and Manabe, 2002)
Runoff	Increasing	7.3 %	(Wetherald and Manabe, 2002)
Water Demand	Increasing	4800 Km^3/Year	(Arnell., 1999)
Temperature	Increasing	0.8 °C to 2.6 °C	IPCC (2007)
Sea level	Increasing	7 to 36 cm	(Roaf, et al., 2005)

III. Conclusions

Climate change has severe influences on world water resources. Each parameter of the water resources are altering .This review paper present the review of some water parameters such as temperature increased (0.8 °C to 2.6 °C), precipitation increased (5.2 %); water demand increased (4800 Km^3/Year), runoff increased (7.3 %) and sea level increased (7 t0 36 cm). All these circumstances are threatening the world water resources.

References

[1]. IPCC (1996) Climate Change 1995, the Science of Climate Change, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

[2]. IPCC (2001) Climate Change 2001. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

[3]. WWF-World Wild Life Foundation (2006) Report for a living planet. Global Footprint Network, Switzerland.

[4]. Reshmidevi, T., Kumar, D.N., Mehrotra, R., Sharma, A., 2018. Estimation of the climate change impact on a catchment water balance using an ensemble of GCMs. J. Hydrol. 556, 1192–1204.

[5]. Arshad, M., Amjath-Babu, T.S., Krupnik, T.J., et al., 2017. Climate variability and yield risk in South Asia's rice–wheat systems: emerging evidence from Pakistan [J]. Paddy Water Environ. 15 (2), 249–261.Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B.B. and Beeregowda, K.N., 2014. Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary toxicology*, *7*(2), pp.60-72.

[6]. Ahmed, K.F., Wang, G., Silander, J., Wilson, A.M., Allen, J.M., Horton, R., Anyah, R., 2013. Statistical downscaling and bias correction of climate model outputs for climate change impact assessment in the US northeast. Global Planet. Change 100, 320–332.

[7]. Rosen, Richard A., Guenther, Edeltraud, 2015. The economics of mitigating climate change: what can we know? Tech. Forcasting Soc. Chang. 91, 93–106.

[8]. World Meteorological Organisation, 1997. Comprehensive Assessment of the Freshwater Resources of the World. WMO, Geneva,34pp.

[9]. IPCC, 2007: Climate Change 2007: The Physical Science Basis, Summary for Policymakers.

[10]. NOAA. 2006. NOAA Magazine. NOAA Reports 2006 Marked by Severe Heat Waves, Widespread Drought, Wildfires. December 14, 2006. www.noaanews.noaa.gov/stories2006 / s2759.htm, accessed August 31, 2009

[11]. NCDC (National Climatic Data Center).2008. Climate of 2007 – in Historical Perspective Annual Report, accessed August 31, 2009.

[12]. Wang, G., et al., 2016. Simulating the hydrological responses to climate change of the Xiang River basin, China. Theor. Appl. Climatol. 124 (3–4), 769–779.
[13]. Kling, H., Fuchs, M., Paulin, M., 2012. Runoff conditions in the upper Danube basin under an ensemble of climate change scenarios. J. Hydrol. 424–425, 264–277.
[14]. Yira, Y., Diekkrüger, B., Steup, G., Bossa, A.Y., 2017. Impact of climate change on hydrological conditions in a tropical West African catchment using an ensemble of climate simulations. Hydrol. Earth Syst. Sci. 21, 2143–2161.
[15]. Seiller, G., Anctil, F., 2014. Climate change impacts on the hydrologic regime of a Canadian river: comparing uncertainties arising from climate natural variability and lumped hydrological model structures. Hydrol. Earth Syst. Sci. 18 (6), 2033–2047.
[16]. Zhang, R., 2015. Integrated Modelling for Evaluation of Climate Change Impacts on Agricultural Dominated Basin (Phd thesis). University Evora, Evora.
[17]. Fournet, S., Krysanova, V., Müller, E.N., Hattermann, F.F., 2014. Comparing impacts of climate change on streamflow in four large African river basins. Hydrol. Earth Syst. Sci. 18, 1305–1321.Munter, r. 2001. Advanced oxidation processes–current status and prospects. *Proc. Estonian acad. Sci. Chem*, 50**,** 59-80.
[18]. Esham, M., Garforth, C., 2013. Agricultural adaptation to climate change: insights from a farming community in Sri Lanka. Mitig. Adapt. Strateg. Glob. Chang. 18, 535–549.
[19]. Su, B., Huang, J., Zeng, X., Gao, C., Jiang, T., 2017. Impacts of climate change on streamflow in the upper Yangtze River basin. Clim. Change 141, 1–14.
[20]. Gbobaniyi, E., Sarr, A., Sylla, M.B., Diallo, I., Lennard, C., Dosio, A., Dhiédiou, A., Kamga, A., Klutse, N.A.B., Hewitson, B., Nikulin, G., Lamptey, B., 2014. Climatology, annual cycle and interannual variability of precipitation and temperature in CORDEX simulations over West Africa. Int. J. Climatol. 34, 2241–2257.
[21]. Pagán, B.R., et al., 2016. Extreme hydrological changes in the southwestern US drive reductions in water supply to Southern California by mid-century. Environ. Res. Lett. 11 (9), 094026.
[22]. Torquebiau, E., 2013. Agroforestry and climate change. In: FAO Webinar, CIRAD–Agricultural Research for Development, 5 Feb 2013.
[23]. Mourato, S., Moreira, M., Corte-Real, J., 2015. Water resources impact assessment under climate change scenarios in mediterranean watersheds. Water Resour. Manag. 29, 2377–2391.
[24]. Mullan, D., Favis-Mortlock, D., Fealy, R., 2012. Addressing key limitations associated with modelling soil erosion under the impacts of future climate change. Agric. For. Meteorol. 156, 18–30.
[25]. Giorgi, F., Coppola, E., Raffaele, F., Diro, G.T., Fuentes-Franco, R., Giuliani, G., Mamgain, A., Llopart, M.P., Mariotti, L., Torma, C., 2014. Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections. Clim. Chang. 125, 39–51.
[26]. Simelton, E., Fraser, E.D.G., Termansen, M., Benton, T.G., Gosling, S.N., South, A., et al., 2012. The socioeconomics of food crop production and climate change vulnerability: a global scale quantitative analysis of how grain crops are sensitive to drought. Food Sec. 4 (2), 163–179.
[27]. Duan, Q., Sorooshian, S., Gupta, V.K., 2015. Optimal use of the SCE-UA global optimization method for calibrating watershed models. J. Hydrol. 158 (3–4), 265–284.
[28]. Eisner, S., et al., 2017. An ensemble analysis of climate change impacts on streamflow seasonality across 11 large river basins. Clim. Change 141 (3), 1–17.
[29]. United Nations Environment Programme, UNEP (ed.) (2003) GEO-Global Environmental Outlook. http://www.unep.org/geo/geo3/English/index.htm
[30]. Todd, M.C., Taylor, R.G., Osborn, T.J., Kingston, D.G., Arnell, N.W., Gosling, S.N., 2011. Uncertainty in climate change impacts on basin-scale freshwater resources – preface to the spetial issue: the quest-gsi methodology and synthesis of results. Hydrol. Earth Syst. Sci. 15, 1035–1046.
[31]. Saseendran, S.A., Ahuja, Lajpat R., Ma, Liwang, 2015. Developing and normalizing average corn crop water production functions across years and locations using a system model. Agric. Water Manag. 157, 65–77.
[32]. Naseela, E.K., Dodamani, B.M., Chandran, C., 2015. Estimation of runoff using NRCS-CN method and SHETRAN model. Int. Adv. Res. J. Sci. Eng. Technol. 2, 23–28.
[33]. Tian, Y., Xu, Y.P., Zhang, X.J., 2013. Assessment of climate change impacts on river high flows through comparative use of GR4J, HBV and Xinanjiang models. Water Resour. Manage. 27 (8), 2871–2888.
[34]. Wetherald, R.T. and Manabe, S., 2002. Simulation of hydrologic changes associated with global warming. Journal of Geophysical Research: Atmospheres, 107(D19), pp.ACL-7.
[35]. Arnell, N.W., 1999. Climate change and global water resources. Global environmental change, 9, pp. S31-S49.
[36]. Roaf V, Khalfan A, Langford M. Monitoring implementation of the right to water: a framework for developing indicators. Berlin: Heinrich Böll Stiftung. 2005 Mar.