Risks and opportunities of REDD+ implementation for environmental integrity and socio-economic compatibility

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Abstract

REDD+ (Reducing emissions from deforestation and forest degradation and the enhancement of carbon stocks) emerges as promising incentive mechanism for tropical forest protection. While REDD+ is expected to yield poverty reduction and biodiversity co-benefits besides emission reductions, its international incentive design options pose several risks to socio-economic compatibility and environmental integrity.

We use an expert survey – ranging from international policy makers to local REDD+ project stakeholders - to rate the perceived significance and likelihood of these risks for national REDD+ implementation. Additionally, the survey asks for the perceived effectiveness of different policy options to minimize these risks. We investigate the risk perception according to regional, topical or stakeholder groupings using cluster and regression analysis.

The results shed light on the most importantly perceived risks to national REDD+ implementation among stakeholder groups and display their views on appropriate policy measures to mitigate these risks. Understanding their perceptions will not only help improving national REDD+ implementation, but also provide insights for the international policy process.

Keywords: deforestation, incentive design, risk perception, biodiversity valuation, REDD+
JEL classification: Q57, O38, D81

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I. Introduction

Deforestation and forest degradation in the tropics contributes approx. 12-20 percent of global greenhouse gas emissions (DeFries et al., 2002; Houghton, 2002; Achard et al., 2004; Houghton, 2005; van der Werf et al., 2009) and acts as major driver of biodiversity loss (IGBP, 1996). Nevertheless, the annual global deforestation rate prevails at approximately 13 million hectares (FAO, 2010). Past policies and measures to reduce deforestation such as the establishment of protected areas, promotion of sustainable land use practices or forest law enforcement have only shown limited success. Previous protection programs mainly failed, since the intensive short-term use of tropical forests for agriculture, forestry and infrastructural development offers greater economic benefits, jobs and food security than their sustainable long-term use (Bonnie et al., 2000; Chomitz et al., 2006).

A recent policy development could fundamentally change this situation. The so-called REDD+ (Reducing emissions from deforestation and forest degradation, and the enhancement of forest carbon stocks) mechanism could provide a successful forest protection option (Santilli et al., 2003). Participants in the REDD+ mechanism would receive financial compensation for reducing greenhouse gas emissions from forest change in developing countries. The process towards a REDD+ mechanism was initiated at the 11th conference of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2005 (UNFCCC, 2005; Gullison et al., 2007). The REDD+ mechanism is still in its planning phase with the aim to fully establish all relevant rules and regulations in the coming years to be functioning for the Post-2012 period of the international climate regime (UNFCCC, 2007a).

Until now these discussions had relatively little focus on REDD+ implementation at the national level (Parker et al., 2009). Nevertheless, the global political framework will ultimately influence the practical realization of forest protection measures. Especially internationally designed rules on REDD+ incentive allocation can largely influence the national effectiveness of emission reductions as well as other desired project impacts.

Besides emission reductions, REDD+ is expected to yield poverty reduction and biodiversity co-benefits (EU_Commission, 2008; Grainger et al., 2009).

In this paper we focus on the effects of international REDD+ incentive design rules on these so-called co-benefits, such as biodiversity protection and the socio-economic well-being of local stakeholders, at the national level. Incentive design rules for the REDD+ mechanism could threaten its environmental integrity by – among others- incentivizing monoculture tree crop plantations with low biodiversity value (Putz and Redford, 2009) or by enhancing the land use pressure on low-carbon ecosystems (Miles and Kapos, 2008). Incentive design rules for the REDD+ mechanism could threaten socio-economic compatibility by – among others - being unable to address poverty as one underlying driver of deforestation (Peskett et al., 2008) or by violating of the rights of local forest-dependent stakeholders (Griffiths, 2007).

So far, the mentioned risks are aimed to be addressed at the international REDD+ policy level by establishing so-called safeguards in the draft negotiation text of the Cancun Agreements (UNFCCC, 2010). Nevertheless, these safeguards will hardly lead to legally enforceable, measurable and monitored international standards for socio-economic and biodiversity aspects of REDD+ and their translation into uniform national rules.

In this paper we argue that assessing the potential effectiveness of international REDD+ incentive design options will require evaluating the associated risks to environmental integrity and socio-economic compatibility at the national level. Parts of the discussed impacts of international REDD+ policy remain hypothetical, since the mechanism still needs to be put in place. However, various pilot projects as well as REDD+ capacity building and early action initiatives such as those under the Forest Carbon Partnership Facility (FCPF) of the Worldbank and the UNREDD program already provide valuable experiences on the risks and opportunities of REDD+ policy design for local or even national implementation. It is of paramount importance to closely examine these experiences in order to inform policy makers at the international and national level on incentive design risks and to discuss solutions to minimize them.

So far, alternatives for designing REDD+ incentive schemes are not yet compared in a comprehensive, quantitative way with regard to the mentioned implementation risks for environmental and socio-economic aspects. This paper aims to draw from the experience of REDD+ stakeholders on the perceived risks as well as on the perceived solutions to overcome these national implementation challenges. As a first step we will determine relevant risks to socio-economic compatibility and environmental integrity under national REDD+ implementation using literature analysis. In a second step we will outline the methodological steps in quantifying the perception of these risks using a REDD+ stakeholder survey. Furthermore, the survey captures the perceived effectiveness of policy options to overcome the mentioned risks. In a third step we will analyze the results and discuss their implications for REDD+ policy negotiations. The results shed light on the perceived risks for national REDD+ implementation and appropriate policy measures for risk mitigation among stakeholder groups. We hope that understanding these perceptions will provide useful information to REDD+ policy makers for designing national REDD+ incentive allocation policies, which ensure effectiveness of emission reductions, socio-economic compatibility and environmental integrity.

II. Literature analysis

A. Selection of risks for the national REDD+ implementation

Risks for the implementation of REDD+ have to be defined based on the goals associated with its implementation. Thus, we analyzed the stated goals in REDD+-related submissions to the UNFCCC by parties in recent years (UNFCCC, 2007b; UNFCCC, 2008; UNFCCC, 2009; UNFCCC, 2010). In the latest REDD+ negotiations at the 16th international climate conference in Cancun all parties acknowledged the importance of reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. They also recognized the importance of forest co-benefits, including biodiversity and the full and effective engagement of indigenous peoples and local communities (UNFCCC, 2010). To remain comprehensive we limited our literature analysis to incentive design risks considered relevant to threaten the goals of environmental integrity and socio-economic compatibility of national REDD+ implementation.

Environmental integrity is here defined as the long term stabilization of forest carbon, the prevention of natural forest conversion and illegal logging, as well as the protection of biodiversity inside and outside of REDD+ areas. Socio-economic compatibility is defined as full and effective engagement of forest-dependent people at the local level (including indigenous peoples), as well as the positive effect on poverty reduction and food security[2]. The chosen nine different risks to cover our definitions of environmental integrity and socio-economic compatibility are outlined in the following section:

1. **Increased land use pressure on carbon-poor ecosystems with high biodiversity outside REDD+ areas**

The choice of forest areas to be protected based on the potential allocation of emission reduction credits does not automatically lead to the highest environmental benefit. REDD+ principally considers the greenhouse gas mitigation potential at the given opportunity costs (=forgone benefits from alternative land use) for the selection of forest areas. This might not coincide with areas of high biodiversity value (Miles and Kapos, 2008). On the contrary, since biodiversity hotspots can have high land use conversion rates (Myers et al., 2000), the costs of conserving these areas might be comparatively expensive for REDD+ (Ebeling and Yasué, 2008). As a consequence, deforestation drivers might shift land use pressure to forest or non-forest areas of high biodiversity but low greenhouse gas mitigation potential, since the benefits from forest protection are comparably low.

[2] Other risks such as inappropriate reference emission level methodologies or international leakage are not dealt with in this paper.. Both aspects could play an important role for REDD+ effectiveness, but they are not directly related to national co-benefit risks from international incentive allocation design. They are thus of limited interest in this study.

2. Conversion of biodiversity-rich forest and non-forest land into plantations due to insufficient forest definitions

The forest definitions under a national REDD+ scheme allow certain interpretation space. Under the current forest definition of the UNFCCC biodiversity-rich, natural forest could be replaced by monoculture, genetically-modified or non-native tree species without being considered deforestation (Putz and Redford, 2010). This might be attractive when the greenhouse gas storage from biodiversity-poor, fast-growing plantations compensates for the greenhouse gas loss (and economic revenue from logging) of natural forest conversion. The terms "sustainable management of forests" and "enhancement of forest carbon stocks", which were confirmed in the scope of REDD+ at COP16 to the UNFCCC (UNFCCC, 2010), still need to be defined. Conversion of open savanna forests into densely-covered unnatural carbon plantations might count as enhancement of forest carbon stocks or even sustainable management of forests (Putz and Redford, 2010). Similarly, afforestation/reforestation (A/F) activities could also take place in biodiverse non-forest ecosystems as enhancement of forest carbon stocks. All these conversions into plantations could result in lower biodiversity and environmental integrity compared to the previous land cover.

3. Continued biodiversity loss due to poaching wildlife and habitat loss in REDD+ areas

The protection of existing carbon stocks of a forest does not necessarily lead to the protection of the biodiversity value of this forest. Especially in regions where poaching of forest mammals and birds or intensive Non-timber-forest-product (NTFP) use takes place, REDD+ measures do not necessarily protect forest biodiversity (Venter et al., 2009). The design, location and size of REDD+ areas might not correspond to habitat requirements of biodiversity at species or ecosystem level and could thus contribute to biodiversity loss, if adjacent areas are deforested or degraded.

4. Continuation of illegal logging practices in REDD+ areas due to insufficient law enforcement

Governance ineffectiveness on national and local level could contribute to illegal logging. REDD+ might reduce the incentive for local stakeholders to engage in illegal activities, when they profit from the carbon payments. However, when weak law enforcement prevails, the incentive for continuation of these illegal activities perpetuates (Kanninen et al., 2007). Illegal logging could manifest in loss of permanence in REDD+ areas or in leakage to poorly monitored areas outside REDD+ projects.

5. Land conflicts & poverty retention due to insufficient involvement of forest-dependent peoples

Many studies (Chomitz et al., 2006; Laporte et al., 2007) support the expectation that REDD+ will lead to poverty reduction, since high percentages of poverty can generally be found at tropical forest margins (Swallow et al., 2007). However, if structural and governance circumstances such as land tenure security and enforcement as well as corruption reduction cannot be ensured, REDD+ might not be successful in poverty reduction (Hall, 2008). The exclusion in planning and revenue sharing for REDD+ measures could even lead to the further marginalization of local land users and indigenous communities (Griffiths, 2007).

6. Increase in land rents and food prices due to REDD+-induced scarcity of agricultural land

REDD+ will provide financial incentives for the protection of forests, which would otherwise have been deforested or degraded. Most of this land use pressure results from demand for agricultural and forestry products. The financial incentives for REDD+ lead to opportunity cost changes for deforestation, so that less agricultural conversions of existing carbon-rich forests can be expected[3]. Consequently, this could lead to the already mentioned effects of land use pressure shift towards low-carbon forests or non-forest areas. If the increment in demand for agriculture and forestry products exceeds the supply from this land, a price increase of those products is likely. The highest

[3] The expectation is only valid, if not a full substitution by international leakage takes place.

agricultural revenues in tropical countries can be obtained from so-called cash crops for exports (Benhin, 2006). If suitable land is occupied with high-profitable cash crops, the opportunity costs for domestic agriculture, especially for low-benefit subsistence agriculture, are thus likely to exceed their economic revenue and to rise in price. The limited availability and high prices of domestic agriculture and forestry goods could disadvantage poor people, which are not able to compensate those increases or substitute their demands. Consequently, poverty and hunger could aggravate for poor people in developing countries (Huettner et al., 2008).

7. Prevention of small-scale REDD+ projects due to high transaction costs

The implementation success of REDD+ on the ground could be influenced by the overall administration and management costs for project design, validation, monitoring and verification involved. Experiences from afforestation/reforestation projects under the Clean Development Mechanism (CDM) show that small-scale projects were often not economically feasible, since the revenue from emission reduction certificates is relatively low compared to the transaction costs. To date there are no validated small-scale CDM forestry projects and investors have shown little interest in financing them (Boyd). Consequently, small-scale projects or projects by low-income communities and individuals are rather unlikely under these conditions (Locatelli and Pedroni, 2006).

8. Ineffective national REDD+ finance distribution due to governance challenges

The effectiveness of national REDD+ implementation is influenced by the scale of its finance distribution. Here the main options consist of incentive distribution via a national focal point to projects versus a nested approach, in which finance could also be directly channeled to projects (Sell et al., 2007). Poor governance conditions such as ineffective law enforcement and corruption are present in many potential REDD+ countries (Ebeling and Yasué, 2008). They potentially threaten revenue channeling from national entities to local level project stakeholders. Additionally, if projects are reliant on national finance distribution by the government, then there is a risk of not receiving credits due to national deforestation rates rising elsewhere (Neef and Ascui, 2009).

9. Non-permanence of REDD+ areas due to rising opportunity costs

The opportunity costs (forgone benefits from alternative land use) of forest protection via REDD+ are likely to change over time. These costs might rise because of the above-mentioned agricultural land scarcity due to the implementation of REDD+ in combination with future growing demand for forestry and agricultural products (Kindermann et al., 2006; Braat et al., 2008). This will increase the supply price for these products and thus change the opportunity costs for forest protection (Sohngen and Beach, 2006). Especially the future demand of cash crops such as palm oil could increase the opportunity costs for REDD+ – making it potentially unprofitable to sustain forest protection measures under REDD+ (Persson and Azar, 2005). Assuming that these drivers of deforestation will perpetuate, there is a need to incentivize forest area stabilization rather than the pure reduction of deforestation and degradation (Mollicone et al., 2007).

III. Materials and Methods

We outline the data collection steps of identifying risks and risk mitigation options using literature analysis and measuring the perceptions of these risks and risk mitigation options using a REDD+ stakeholder survey. To analyze the survey results we used cluster analysis, linear regression analysis and multi-factorial analysis of variance (ANOVA), which are briefly described in this section.

B. Data collection

Literature review: We chose nine different risks derived from literature analysis to cover our definitions of environmental integrity and socio- economic compatibility. Risks to these political goals were investigated based on research articles, as well as scientific reports and policy documents in the field of REDD+ implementation. In a latter step of this study we selected the most common REDD+ policy options to minimize the chosen risks based on a similar form of literature analysis. Here we distinguished voluntary and mandatory as well as incentive and regulatory policy options. Regulatory (also sometimes named command—and—control) policy refers to environmental regulation (such as permission, prohibition, standard setting and enforcement) as opposed to incentive policy, which refers to economic instruments of cost internalization (OECD and FAO, 2008).

Given the subjective determination of risks and policy options based on literature analysis, the representativeness of the selection can be questioned. We thus allowed participants of the conducted REDD+ stakeholder survey to complement information considered relevant. All risks are described in detail in the first part of the results section.

Online survey: We conducted an online survey with REDD+ stakeholders ranging from international policy makers, researchers, lobbyists and practitioners. Stakeholders were asked to rate the perceived significance and likelihood of the introduced risks and the perceived effectiveness of the mentioned REDD+ policy options to minimize these risks. The survey was accessible online between April and August 2010.

In the survey we distinguished nine risk sections, that each consisted of the following three parts: (1) Rating of the estimated risk significance (i.e. perceived importance of negative consequences to the success of REDD+, if the risk happens) and risk likelihood (i.e. perceived probability of the risk occurring in participants country over the next 30 years); (2) Rating of the estimated effectiveness of policy measures to minimize the above-mentioned risks; (3) Provision of additional comments, if the policy choices provided in the second section were regarded insufficient or if general remarks were anticipated. The Annex provides a template of the survey questionnaire.

Potential participants were selected based on contact information from official UNFCCC/ SBSTA representation, large development and environmental non-governmental organizations, international organizations such as FAO or OECD and business organizations active in forest carbon projects. All contacts were invited by e-mail with personalized invitation codes to avoid abuse by unintended participants or multiple participations. Participants were ensured anonymity to limit strategic or political bias in the answers. Out of 363 invited participants we had a total response rate of 49 percent, of which 92 participants provided a complete and 86 an incomplete survey. We only considered the fully completed surveys in order to allow for an unbiased comparison of the results[4].

C. Data analysis

Risk perception factor: In principle, we can never operationally define risks but rather only the individual risk perception (Holton, 2004). For each risk and each participant we calculated a risk perception factor (RPF) based on the product of the survey rating for the estimated risk significance and risk likelihood, as commonly applied in risk assessment and management science (Claassen et al., 2008). To control for non-linear relationships between the estimated risk significance and risk likelihood we requested a ranking of the risks at the end of the survey, which then could be compared to the calculated ranking based on the previously rated risk significance and risk likelihood product.

Cluster analysis: In order to explore possible groupings in the risk perception among survey participants we applied cluster analysis. We performed the Ward hierarchical cluster analysis, since this method provides generally good results compared to other clustering options (Milligan and Cooper, 1987). For the similarity measure we applied symmetric Euclidian distance measures to determine the relatedness among stakeholders based on all 9 individual risk perception factors. Ward's method groups the original observations in more aggregated groups in order to minimize the within-group variance and to maximize the intergroup variance. The results are presented in Figure 1. A visual inspection of the dendrogram suggests two different groups of risk perceptions among stakeholders. While a further differentiation of cluster groups is generally possible, the resulting low number of individuals per group would hamper their subsequent statistical analysis.

[4] This is because the survey was presumably left incomplete for different reasons such as shortage of time, perceived lack of expertise to answer certain questions, or ignoring important information on profession, working countries, etc.

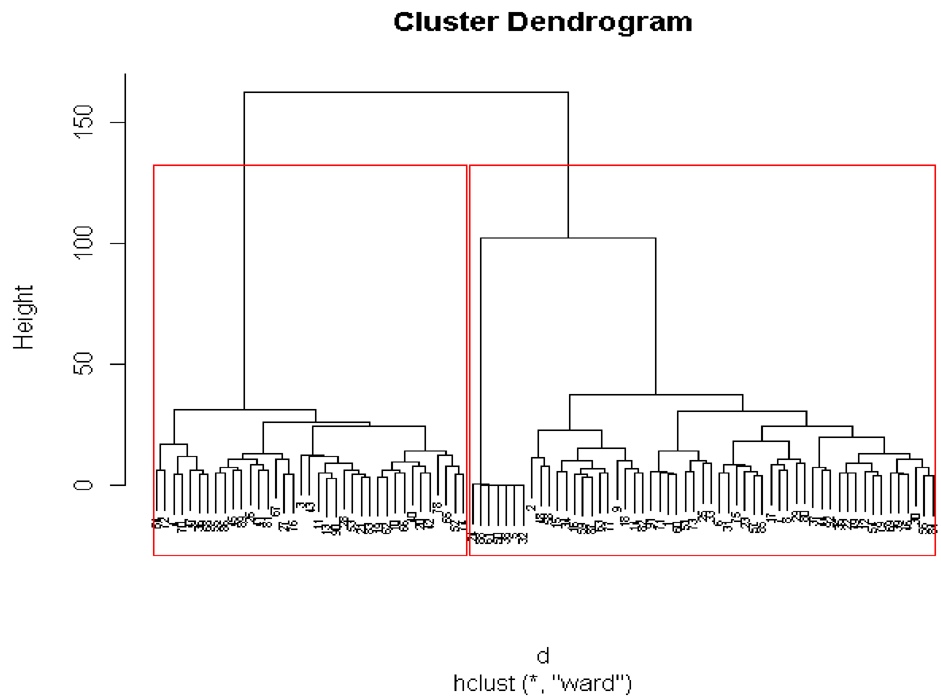

Figure 1: Dendrogram of the proximity (height) between individual risk perception factors for all nine risks using Ward hierarchical clustering

To test the validity of grouping the individuals according to similarity in their risk perception factors (RPF) in two clusters, we apply the Wilcoxon-Mann-Whitney (U-) test (two-tailed). This non-parametric test compares if the risk perception factors are significantly different between the two clusters (rejecting the null hypothesis). Table 1 provides the descriptive statistics.

	Cluster1 mean RPF	***Cluster2 mean RPF***	***W***	***p-value***
risk1	2.47	3.75	6272	0.000
risk2	3.15	4.65	6403	0.000
risk3	2.87	4.08	6365	0.000
risk4	4.09	5.45	7230	0.000
risk5	3.90	5.34	7083	0.000
risk6	1.88	2.90	5592	0.000
risk7	2.92	3.97	6337	0.000
risk8	5.01	6.17	7470	0.000
risk9	2.82	4.13	6531	0.000

Table 1: Mann–Whitney (=W) values for all individuals in cluster 1 (n1=55) and cluster 2 (n2=37)

The distributions of the individual RPF in the two clusters in Table 1 differ significantly ($p < 0.05$). The same is true when comparing the summed RPF mean values for cluster 1 and cluster 2 (Mann–Whitney W = 14, n1 = n2 = 9, p = 0.0188, two-tailed). We thus calculate the subsequent statistical analysis separated for each cluster in order to pre-stratify the results for the statistical analysis according to risk perception differences.

Statistical analysis: For each cluster we investigated whether the risk perception is dependent on group characteristics of REDD+ stakeholders. These characteristics (requested in the survey questions 1 to 5; see the survey template in the Annex) are described in Table 2.

#	Stakeholder characteristics	Variables
A	Main REDD+ working region	International, Asia, Latin America, Africa, Oceania
B	Location of organization	Annex-1 country, Non-Annex-1 country
C	Profession	Academia, Business, Governmental, Non-Governmental
D	Field of REDD+ expertise	National REDD-policy design, International REDD+ policy design*, REDD+ project implementation, Mainly theoretical REDD+ research
E	Experience in REDD-related work	0-2, 2-4, 4-6, 6-8, 8-10, more than 10 years

*Table 2: Group characteristics of REDD+ stakeholders; *includes NGO-work such as awareness raising and critical observation of national and project activities*

We apply multiple linear regression analysis to investigate the correlation among risk perception (dependent variable) and each stakeholder characteristic consisting of several options (independent variables). The independent variables are binary or dummy coding was used for the transformation of continuous into binary variables. We substituted the individual RPF values for each risk with their deviation from the individual mean RPF over all risks. This allowed accounting for individual scaling behavior for the rating and for a normalized distribution of residuals. The regression results are displayed in Table A in the Annex.

The multiple regression analysis tests whether the specific average RPF deviation of each stakeholder group is significantly different from the overall average RPF deviation value for all risks[5]. This provides an indication for the absolute risk perception by each stakeholder group in relation to all other risks. However, in order to test whether the perception of each risk differs significantly among stakeholder groups, we need to apply a multi-factorial analysis of variance (ANOVA) in combination with a Tukey test. Again, we specify the model by using the individual RPF´s deviation for each risk from the individual mean RPF for all risks as dependent variable. We test whether the risk perception among REDD+ stakeholders differs based on their characteristics of profession, expertise, or main working region. These characteristics form the independent variables of the ANOVA. To fit the model we tested for potential interaction effects among the independent variables.

[5] which is equal to zero

IV. Results

A. REDD+ stakeholder survey - risks to national REDD+ implementation

The previous literature-based selection of risks alone cannot provide insights concerning their potential likelihood and significance. We therefore launched a REDD+ stakeholder survey to quantify the perceived importance of these risks. The average individual risk perception factors (RPF) from the survey are summarized in Figure 2.

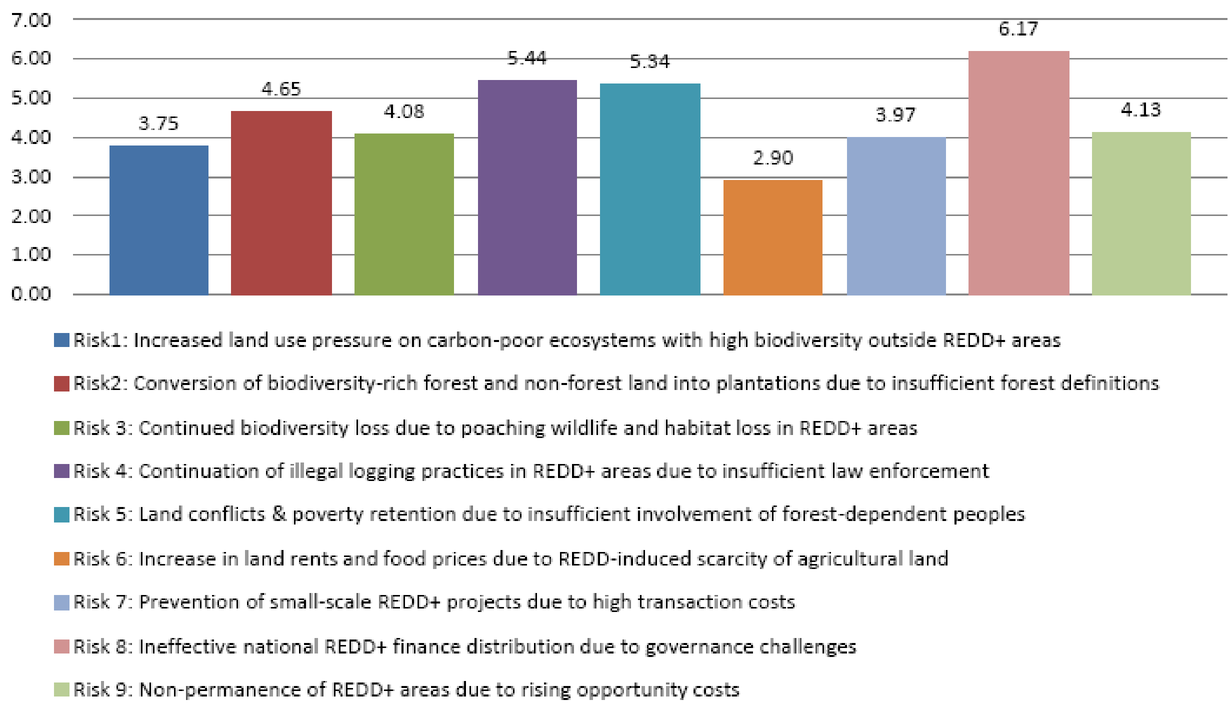

Figure 2: Average risk perception factors for all participants from REDD+ stakeholder survey

Given that participants had to rate the perceived risk likelihood and significance from a scale between 1 and 10 (with 10 corresponding to the highest risk values) Figure 2 shows that only three risks obtain a RPF score above average. Of these, risk 8 can be described as highly relevant with a value higher than 6. However, the scoring also reveals that none of the mentioned implementation risks was perceived totally irrelevant.

When breaking the average RPF values according to the rating distribution we obtain a more differentiated picture as outlined in Figure A in the Annex. Here we can distinguish between risks with a general decline towards high RPF (e.g. risk 5) and risks with a general increase towards high RPF (e.g. risk 8). The majority of the envisaged risks however display a rather mixed RPF distribution. In the extreme case risks received almost the similar amount of very high and very low RPF ratings (e.g. risk 2).

Why are certain risks perceived very important by certain stakeholders while others neglect their relevance? Are these different risk perceptions related to characteristics of REDD+ survey stakeholders? To answer these questions, we first stratified the survey data using cluster analysis. The cluster analysis divides the survey sample into two distinct groups according to their average RPF values as shown in Table 3.

	risk1	*risk2*	*risk3*	*risk4*	*risk5*	*risk6*	*risk7*	*risk8*	*risk9*
Average RPF for cluster 1	2.47	3.15	2.87	4.09	3.90	1.88	2.92	5.01	2.82
Average RPF for cluster 2	5.65	6.87	5.88	7.46	7.48	4.42	5.54	7.88	6.08

Table 3: Average risk perception values for cluster 1 and 2

Individuals in cluster 1 show a significantly lower risk perception than individuals in cluster 2. We therefore label individuals in cluster 1 as “risk-neutral”, while participants in cluster 2 are labeled “risk-sensitive”. We then employed a linear regression model on the relationship between risk perception value and the mentioned stakeholder characteristics. Its results are displayed in Table A in the Annex for both clusters. While the linear model indicates, if risk perceptions are influenced by differences in group characteristics, we ran an ANOVA with a Tukey-Test to explore, which stakeholder characteristics provide significant explanatory power for these differences[6]. The results of the ANOVA and the Tukey-Test (and the observed significant interaction effects) are displayed in Annex-Table C and D respectively.

We restrict the interpretation of the statistical analysis to – in our view – interesting results to remain comprehensive and focused on the goal of our research. The values in brackets represent the rating deviation from the respective individual average RPF values for the linear regression model. They provide a robust indicator, if a risk is

[6]` Experience` proofed to be mainly insignificant as independent variable, so it was left out in the ANOVA.

perceived high or low in relative terms. Significance values relate to alpha smaller than 1% (***), 5% (**) and 10% (*) for the linear regression model, and alpha smaller than 0.1% (***), 1% (**), 5% (*) for the ANOVA and Tukey-Test respectively. Values for Oceania are left un-interpreted due to its low n values.

1. **Increased land use pressure on carbon-poor ecosystems with high biodiversity outside REDD+ areas**

For stakeholders from all REDD+ working regions risk 1 is perceived relatively unimportant, although this is only significantly different from their average RPF deviation value for stakeholders from Latin America (-1.019**) in cluster 1. Regarding their profession, only participants from the NGO-sector rated this risk significantly below average, especially those working on REDD+ project implementation (cluster 1) or theoretical REDD+ research (cluster 2). However, while the linear model revealed some significant deviations from the average stakeholder rating, the ANOVA finds no significant explanatory group characteristics.

2. **Conversion of biodiversity-rich forest and non-forest land into plantations due to insufficient forest definitions**

Risk 2 shows very heterogeneous results among stakeholder groups. Regarding the field of REDD+ expertise, participants working in international REDD+ policy design rated this risk significantly higher than average (2.337***, cluster 2). Opposite, national REDD+ policy design stakeholders regarded this risk rather low. The Tukey-Test revealed that NGO rate this risk higher than business, although the ANOVA provides only weak support for this claim.

3. **Continued biodiversity loss due to poaching wildlife and habitat loss in REDD+ areas**

Again, stakeholders from Latin America consider this risk to be relatively low (-0.999*; cluster1). This seems especially relevant for people working in academia (-0.995**; cluster1) and governmental actors (-1.894***; cluster2). The latter is supported by the ANOVA and Tukey test, according to which governmental stakeholders perceive this risk significantly lower than business actors (cluster 2).

4. **Continuation of illegal logging practices in REDD+ areas due to insufficient law enforcement**

Interestingly, this risk was perceived significantly above average from people working mainly internationally, in Africa (for cluster 1 and 2) or Asia (for cluster2), but not in Latin America. When viewing the differences among groups in the ANOVA, South-American stakeholders rated the risk of illegal logging significantly lower than their colleagues from Africa and globally working REDD experts - both for all stakeholders and cluster 1. In general, stakeholders from Annex-1 countries perceive this risk much higher than colleagues from Non-Annex-1 countries. Surprising to our expectation was that in the risk-sensitive cluster governmental agents show the highest rating (2.056***). However, we could not find significant differences of governmental agents compared to other groups in the ANOVA, which indicates the large variability in their RPF ratings in cluster 2. For cluster 1 we mainly see high risk perceptions from business (1.572**) and NGO (1.457***) in the linear regression model, which is confirmed by the ANOVA results. Here, governmental stakeholders show a significantly lower risk perception than business and NGO actors. For the risk neutral cluster there are also interaction effects of business stakeholders from Asia and internationally, who perceive this risk significantly higher than governmental stakeholders from these regions.

5. **Land conflicts & poverty due to insufficient involvement of forest-dependent peoples**

Participants from Asia (1.637***), Africa (1.286***) and internationals (1.471***) showed above-average risk perceptions in the risk-sensitive cluster. In its absolute ratings risk 5 is very similar to risk 4, although here the risk perception is significantly above average for all profession groups (academia, business, governmental, NGO) – at least for the risk-sensitive cluster. As expected, this risk is perceived relatively high by NGO stakeholders (0.961***; cluster 2), though the highest rating comes from academic scholars (1.572***; cluster 2). For governmental actors we even see significant positive results for cluster 1 (1.157***) and cluster 2 (1.094*). Interestingly, the high risk perception is limited to scholars with mainly theoretical expertise such as national

REDD-policy design (1.094**) and REDD+ research (1.81***) in cluster 2. However, despite these outcomes of the linear model the group characteristics proved insignificant in explaining risk perception differences in the ANOVA. Here, only the results for the risk-sensitive cluster suggest a significantly lower risk perception by REDD scholars working on policy and implementation in South-America compared to international scholars in these fields.

6. Increase in land rents and food prices due to REDD+-induced scarcity of agricultural land

Risk 6 is the lowest perceived risks in absolute terms. The low significance of this risk manifests through almost all REDD+ working regions and professions. However, regarding the field of REDD+ expertise, only participants active in REDD+ project implementation show significantly negative deviations from their average RPF rating (-0.807*; cluster1 / -1.587**; cluster 2). There are no significant risk perception differences among groups.

7. Prevention of small-scale REDD+ projects due to high transaction costs

Risk 7 is perceived relatively low by internationally working REDD+ stakeholders (-2.419***), especially those working in academia (-3.648***) in the risk-sensitive cluster. While South American REDD+ actors have previously shown a very low risk perception regarding governance risks, the ANOVA reveals that they are significantly more concerned regarding the implications of high transaction costs for small-scale REDD+ projects compared to their fellows working in Africa or internationally (all data and cluster2). While people in international REDD+ policy design view this risk to be low (-0.939*; cluster 1 / -2.034***; cluster 2), stakeholders working in the practical REDD+ project implementation perceive this risk relatively high (1.272**; cluster 1). We also find support for these linear regression results indicating a higher risk perception from actors involved in implementation compared to pure policy experts in the ANOVA – both for all data and cluster 1. This result is also supported by the significantly lower risk perception rating by academic scholars compared to business, governmental and NGO actors in cluster 2.

8. Ineffective national REDD+ finance distribution due to governance challenges

Risk 8 is clearly perceived as the most severe risk for the national implementation of REDD+. As expected perceptions are somewhat similar to risks 4 and 5, which are also related to governance aspects. Participants from all REDD+ working regions (except Oceania) rate this risk significantly above average for both clusters. Scholars from Annex-1 countries rate this risk significantly above average for both clusters. However, it is noteworthy that even for Non-Annex-1 countries no other risk shows a higher positive deviation from the average RPF rating (1.388***, cluster 1). Across all professions risk 8 is perceived relatively high, with business (2.006**; cluster 1) and NGO´s (2.111***; cluster 1) having the highest values. Counter-intuitively, even governmental scholars rated this risk clearly above average (1.586***; cluster 1 / 1.756***; cluster 2). To our surprise we did not find significant results for survey participants active in REDD+ project implementation. Here, the highest risk perception was obtained from international (1.957***, cluster 1) and national (1.155**; cluster 2) REDD+ policy design stakeholders. There are no significant differences in the risk perception among groups of stakeholder characteristics observable in the ANOVA, most likely because all stakeholder groups show more or less comparable positive risk perception ratings.

9. Non-permanence of REDD+ areas due to rising opportunity costs

Risk 9 is not significantly positive above average and rather heterogeneously perceived (which is also visible in Figure A in the Annex) with only a few significant values in the risk-neutral cluster. Stakeholders working mainly in the international arena (-1.26**; cluster 1), in Annex-1 countries (-0.765**; cluster 1) and in the NGO profession (-1.343**; cluster 1) are the only ones, who clearly rate this risk below average. The ANOVA results support the restriction of relevance of risk 9 to the risk-neutral cluster 1. Here, NGO show a significantly lower risk perception than academic scholars. Also, Latin-American REDD experts show a higher risk perception than their internationally working colleagues.

B. REDD+ stakeholder survey - effectiveness of REDD+ policy design options

Besides their risk perception, REDD survey participants were asked to rate a set of policy options in their effectiveness to mitigate these risks (with 0 as the lowest and 10 as the highest rating). These options were based on literature analysis – additionally participants could complement policy options, if regarded necessary. However, no alternative appeared in sufficient number to add to our initial set of options. The summarized results of the policy option rating are displayed in Table B in the Annex.

In this section we only introduce the general findings and leave the analysis of potential political implications to the discussion section.

The results for the perceived effectiveness of policy options to mitigate the before-mentioned risks allows for a more general grouping. Survey participants regarded mandatory policies superior to voluntary policies, where both options were present in the selection (all but risks 2 and 8). For all risks, where both voluntary regulation and voluntary incentive policy options were present, the incentive policies always scored higher effectiveness ratings. In the case of mandatory policy options we cannot find such clear results. For risks 1, 3, 4, 6 and 9 the incentive policy is perceived the most effective solution – although sometimes only with a slightly higher score than mandatory regulatory policy (as for risks 6 and 9). For risk 2 the mandatory regulatory policy (here: the exclusion of plantation forestry under the REDD+ scope) is seen as the most effective policy option for risk minimization.

It should be noted that policy options to mitigate the most dangerously perceived risk (risk 8: Ineffective national REDD+ finance distribution due to governance challenges) did not employ policy concepts, which could be clearly labeled as mandatory or voluntary, nor as regulatory or incentive type. Instead, the question of effective finance distribution differs in the role of institutions involved in channeling funds. Here, it is noteworthy that the policy option currently envisaged under the UNFCCC (REDD finance channeling via a national government focal point) is expected to yield the lowest effectiveness (4.77), while the rather incentive-related option of third-party verification of REDD finance transfer effectiveness gained the highest support (7.29).

V. Discussion

The REDD+ stakeholder survey offered a possibility to quantify the significance of the perceived main risks for the national implementation of a future REDD+ mechanism. The subjective step of risk and policy option selection based on literature analysis can be justified for two reasons apparent from the assessment of the survey. First, the participants only sporadically used the possibility to add missing elements in the comments section. Second, none of the average risk and policy option ratings points towards insignificance.

The wide variety of stakeholder characteristics allowed for a differentiated analysis of the survey results. First of all, the total pool of 92 participants can be split into two clusters, representing rather risk-neutral individuals for cluster 1 and rather risk-sensitive individuals for cluster 2. However, this clustering does not allow for a simplified division according to stakeholder characteristics such as general risk sensitivity of NGO stakeholders on the one hand and risk-neutrality of governmental stakeholders on the other hand. In contrast, the results of the regression analysis and ANOVA reveal a much more differentiated picture.

A. Perceived risks for the national implementation of REDD+

The highest RPF scores were obtained for the socio-economic risks of ´ineffective national REDD+ finance distribution due to governance challenges` (risk 8), `continuation of illegal logging practices in REDD+ areas due to insufficient law enforcement` (risk 4) and `land conflicts & poverty retention due to insufficient involvement of forest-dependent peoples` (risk 5). All these risks have in common that they deal with governance challenges at the national (and apparently also the local) level. The importance of governance challenges for REDD+ is confirmed from various lessons-learned in REDD+ pilot project implementation (Harvey et al., 2010).

The risk of illegal logging (risk 4) was perceived higher by NGO and business professionals compared to governments. Still governmental actors consider this risk to be exceptionally relevant. The significantly lower risk perception by REDD+ professionals working in Latin America compared to their peers working in Africa, (Asia) and internationally leaves room for interpretation. It could possibly be related to the drivers of deforestation. While Africa and Asia are mainly threatened by logging, forest loss in Latin America is largely attributed to livestock, agriculture and infrastructure (Geist and Lambin, 2002). Similarly, the insufficient involvement of forest-dependent people (risk 5) was perceived relatively high by stakeholders located in both Annex-1 and Non-Annex-1 countries – including agents from governmental organizations. However, not those who practically work on the ground, but instead scholars who mainly work on theoretical REDD+ research rated this risk superior in its significance. Ineffective national REDD+ finance distribution due to governance challenges (risk 8) is perceived with clearly higher above-average ratings by survey participants whose organization is located in Annex-1 countries. But similar to the two previous risks, there are also high scores for governmental stakeholders – even from developing countries. These results show that governmental agents in tropical countries are aware of the governance challenges faced for the implementation of REDD at the national and local level.

Risks to environmental integrity (risks 1-3) received lower average perception scores than the previous group (risks 4, 5, 8). Biodiversity loss due to increased land use pressure on carbon-poor ecosystems with high biodiversity outside REDD+ areas (risk 1) is generally viewed as of low significance, especially from those working in project implementation. This could be due to the fact that REDD+ projects has not yet reached a magnitude, where pressure for land use conversion could be widely experienced.

The risk of biodiversity-rich forest and non-forest land conversion into plantations due to insufficient forest definitions (risk 2) is perceived very high by survey participants working in international REDD+ policy design. Opposite, national REDD+ policy design stakeholders rate this risk below average (though only at alpha of 10%). This dichotomy can be explained by the importance of forest definitions on the international REDD+ policy agenda, while on the other hand plantation establishment and the current broad forest definition under the UNFCCC might seen as opportunity instead of a risk for many national REDD+ policy makers (Parker et al., 2009).

The only risk, which is on average rather perceived insignificant, is the `increase in land rents and food prices due to REDD-induced scarcity of agricultural land` (risk 6). This might – similar to risk 1 – be explained with the lacking experience for such risk, whose realization is dependent on large-scale implementation of REDD+ at the national level, which might furthermore be seen unlikely in the near future.

Risk 7 (Prevention of small-scale REDD+ projects due to high transaction costs) is a typical business risk, which however has a socio-economic rationale nonetheless. The higher the transaction costs, the harder it will be for local stakeholders to establish REDD+ projects on their own. While this risk seems to be especially low for academics and people working in international REDD+ policy design, it is perceived significantly important by REDD+ project practitioners. It can be argued that stakeholders active in the practical implementation have a more realistic perception, since they are directly confronted with this risk in their day-to-day work.

Non-permanence of REDD+ due to rising opportunity costs (risk 9) is on average not perceived relatively high. Like risk 6 it is conditional on long-term changes in land use pricing and is thus difficult to assess. This might – at least in part - explain the majority of insignificant average RPF ratings. REDD+ stakeholders working in Latin America might perceive this risk more relevant than their international peers, since the dominance of highly profitable agriculture might make the issue of opportunity costs much more prominent.

B. Perceived effectiveness of REDD+ policy design options

To properly assess the perceived effectiveness of REDD+ policy options, one should be aware that policy options within and among risks do not need to be mutually exclusive. Measures like regulatory and incentive policies could co-exist and even complement each other in various cases. Also several mandatory regulatory policy measures could co-exist such as the exclusion of plantation forestry under the REDD scope and the exclusion of natural forest conversion under forest-related definitions. When further analyzing these matching pairs it is however important to distinguish between policy options, which are designed at the national and at the international level.

As we have shown, several socio-economic risks for the national implementation of the REDD+ mechanism are perceived important across most stakeholder groups. The policy option results imply that on average survey participants would prefer mandatory incentive policy measures to overcome these governance challenges.

In the case of `continuation of illegal logging practices in REDD+ areas due to insufficient law enforcement` (risk 4) this means that the negative incentive option of financially punishing for non-permanence or leakage is seen as most effective risk mitigation measure. This preferred option also applies to the risk of `non-permanence of REDD+ areas due to rising opportunity costs` (risk 9). Also mandatory regulatory policy measures, such as in-project risk reduction measures (e.g. buffer areas, insurance reserves), received high effectiveness scorings. Support for these measures might be explained by their best-practice character in already established voluntary forest carbon projects (CCBA, 2010).

To overcome `land conflicts and poverty retention due to insufficient involvement of forest-dependent peoples` (risk 5) the most attractive policy measure were `mandatory international REDD safeguards prior to implementation (prior informed consent, clearly defined ownership and use rights) and mandatory governance control measures such as independent third-party monitoring. Both options could be complemented, though the latter would rather concern the project or the national level. This could complicate its successful negotiation internationally.

To overcome `ineffective national REDD+ finance distribution due to governance challenges` (risk 8) there is again strong support for third-party verification. Additionally, the (second-highest rated) mandatory national liability mechanism for dispute resolution (e.g. on transfers, ownership) could be used complementary. On average survey participants clearly supported a REDD+ finance mechanism, which allows for direct REDD finance channeling from international to project level instead of using the national government as intermediate. This again might be related to the highly perceived risk of governance challenges at the national and local level, which also mirrors in REDD+ project experiences (Peskett et al., 2008).

REDD+ stakeholders in the survey expect that risks for the environmental integrity (risks 1 and 3, to a lesser extent risk 2) could best be mitigated by using mandatory incentive policies to protect biodiversity. These could be realized through e.g. extra payments for biodiversity under a REDD+ fund or a hybrid-market mechanism (see e.g. (Hare and Macey, 2007)). In a previous paper we have shown how the harmonization of carbon and biodiversity incentives could be designed for REDD+ (Obersteiner et al., 2009). Mandatory incentive policies to protect biodiversity were also perceived suitable to prevent `non-permanence of REDD+ areas due to rising opportunity costs` (risk 9), since additional payments for the protection of biodiversity would help to buffer the envisaged investment risks.

To overcome the risks related to insufficient forest definitions participants favored the exclusion of plantation forestry and of natural forest conversion under the REDD scope, but also considered incentive schemes for biodiversity protection relevant. Again, these regulatory and incentive policies do not exclude each other – they could rather form synergies to increase the effectiveness of biodiversity protection measures for the national REDD+ implementation.

While the `increase in land rents and food prices due to REDD-induced scarcity of agricultural land` (risk 6) is not expected to constitute a significant risk, participants favor incentive policy measures such as a national investment programs into agriculture intensification or mandatory national negative incentive policy (e.g. tax, penalty) against the conversion of subsistence agricultural land. Opposite to most policy options, these would need to be individually designed at the national level in order to account for country-specific circumstances, such as country-specific deforestation drivers (Lambin et al., 2003).

C. Limitations of the research approach

Risks are inherently difficult to quantify - especially for a mechanism, which still needs to be established. This paper does not claim to provide a comprehensive list of possible risks for national REDD+ implementation. Rather, one has to be aware that our results build on subjective perceptions of a fraction of REDD+ stakeholders. Although we restricted the survey to online access we claim that the possible selection bias is rather negligible. Given the relatively small pool of REDD+ experts worldwide we received a large variety of stakeholder characteristics in the replies – indicating that we did not just sample a subset of stakeholders.

We also need to pinpoint to the fact that risk and policy effectiveness ratings not only differed due to heterogeneous perceptions but also due to country- or even region-specific characteristics such as governance effects and deforestation drivers. However, the total number of respondents did not allow for a country–specific statistical analysis with all possible influencing factors. But since we control for the main working region we hope to capture most of this heterogeneity.

D. Implications for REDD+ policy

The last years saw an explosion in REDD+ projects and respective research literature analyzing the challenges for building a functioning REDD+ mechanism. The REDD+ discussion benefited from existing qualitative comparisons of international climate policy options in (Aldy et al., 2003). In a later stage more specific comparisons of international REDD+ policy options evolved as well (Angelsen et al., 2009). Qualitative analysis of REDD+ risks at the national level is for example provided by (Seymour, 2008) and (CIFOR, 1999). Comprehensive attempts to quantify risks for national REDD+ implementation are however lacking so far. Existing work is rather case study specific such as (Oestreicher et al., 2009) or does not take into account the national level explicitly (see e.g. (Angelsen et al., 2009)). The use of REDD+ expert surveys on national implementation risks is also a novel approach. So far, there are only expert survey applications on REDD baselines by (Huettner et al., 2009), or on protection effectiveness for national REDD implementation from Panama (Oestreicher et al., 2009).

Our approach is novel in drawing from REDD+ stakeholder expertise to quantify their perception of risks and risk mitigation effectiveness. This allows for a more in-depth comparison and prioritization of policy measures to tackle the risks, which are perceived to be most pressing.

Despite the mentioned limitations our study allows to discuss possible implications for designing REDD+ policy measures to minimize implementation risks at the national level. Since we limited our study to environmental integrity and socio-economic compatibility we also need to discuss possible adverse effects of minimizing these risks for political feasibility in general and emission reduction success in specific (Harvey et al., 2009). Our study indicates that REDD+ projects could fail to improve or even have an adverse effect on environmental integrity and socio-economic compatibility. Minimizing the associated risks would most of the time come at additional costs for administrative measures (for regulatory measures such as socio-economic or biodiversity safeguards, which need to be monitored) or financing (incentive mechanisms such as additional biodiversity payments). For a successful negotiation of environmental and socio-economic risk mitigation measures under the UNFCCC it will be crucial to consider the cost issue seriously. However, this need not be a disadvantage for REDD+ policy negotiations. There is a growing demand for high quality forest carbon credits (EcoSecurities, 2010) and also business and industrialized country governments show increased interest in valuation of forest ecosystem services besides carbon (EU, 2008; Madsen et al., 2010). Thus, industrialized countries are challenged to institutionalize this demand to tap predictable and additional revenue streams for biodiversity and socio-economic incentives besides carbon credits. This could e.g. be done by offering fixed premiums for successfully achieving and monitoring safeguards (Obersteiner et al., 2009). The willingness of developing countries to adopt mandatory regulatory or incentive policies will largely depend on the confirmation of predictable funding for such avenue by industrialized countries.

There are however also policy measures, which could be effective in minimizing certain risks without involving large investments. These include the exclusion of plantation forestry and natural forest conversion under the REDD scope to prevent the loss of biodiversity-rich forest and non-forest land (risk 2). Another example concerns the option of simplifying international rules and regulations for small-scale REDD projects to lower the transaction costs for them (risk 7).

VI. Conclusions

Besides emission reductions, REDD+ is expected to yield poverty reduction and biodiversity co-benefits. However, depending on the design of a future international REDD policy mechanism, several risks could hamper the environmental integrity and socio-economic compatibility of its implementation at the national level.

In this study we argue for taking these risks into account in order to effectively design national REDD+ incentive schemes. We draw from the experience of REDD+ stakeholders on the perceived risks as well as on the perceived effectiveness of policy solutions to assess these national implementation challenges. As a first step, we determined relevant risks to socio-economic compatibility and environmental integrity under national REDD+ implementation using literature analysis. In a second step, we quantified the risk perception using a REDD+ stakeholder surveys. Furthermore, the survey captured the perceived effectiveness of incentive design options to overcome to mentioned risks. In a third step we analyzed the results and discuss their implications for the REDD+ policy negotiations.

On average, the survey revealed a much higher risk perception concerning socio-economic compatibility compared to environmental integrity. Especially governance-related challenges such as ineffective national REDD+ finance distribution, the continuation of illegal logging practices in REDD+ areas as well as land conflicts and poverty retention due to insufficient involvement of forest-dependent peoples were viewed as serious challenges for national REDD+ implementation. Our regression results indicated that stakeholder characteristics such as profession, main working region, and the main field of work play a role for the individual risk perception. However, these results do not allow for a generalized categorization of risk perceptions based on stakeholder characteristics, since these perceptions are strongly risk-specific.

On average, the surveyed REDD+ stakeholders preferred the use of mandatory incentive and regulatory policy options over voluntary ones to overcome these risks. Several positively rated policy options even allow for synergies, when applied jointly. Some of these options would challenge policy makers to consider new avenues of REDD+

financing, such as biodiversity safeguard payments, while others can be achieved at relatively low costs.

We believe that a careful reflection of the investigated stakeholder experiences can provide insights for designing REDD+ policy, which lowers the implementation risks and improve the environmental and socio-economic effectiveness for national REDD+ actions.

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ANNEX

Table A: *Multiple regression of the dependency of deviation of the clustered risk perception factors from its individual mean on stakeholder characteristics*

	Multiple regression model	**Risk 1**		**Risk2**		**Risk3**		**Risk 4**		**Risk 5**	
		Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2
Stakeholder characteristics	Independent binary variables:	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
Main REDD+ working region	International	-0.517	-0.179	-0.36	1.051	0.176	-0.669	1.904***	1.011*	0.376	1.471***
	Asia	-0.188	-0.897	0.887	-0.13	-0.447	-1.213	0.028	1.637**	0.678	1.637***
	Latin America	-1.019**	-0.518	-0.372	0.791	-0.999*	-0.7	-0.132	0.4	0.641	0.355
	Africa	-0.817	-1.334*	-0.025	0.046	-0.333	0.376	1.75***	1.616***	0.817	1.286***
	Oceania	-3.74***	NA	-2.19	NA	0.81	NA	0.51	NA	1.91	NA
Location of organization	Annex-1 country	-0.687*	-0.71	-0.109	0.503	-0.152	-0.568	1.332***	1.199***	0.326	1.215***
	Non-Annex-1 country	-0.873**	-0.706	-0.051	0.525	-0.669	-0.329	0.192	0.902*	1.14**	0.932**
Profession	Academia	-0.782	-1.088	0.28	0.792	-0.995**	-0.368	0.893*	1.772**	0.542	1.572**
	Business	-0.739	-1.274	-0.772	-1.414	-1.294*	1.226*	1.572**	1.046	0.472	1.286*
	Governmental	-0.49	-0.506	-0.355	0.156	0.128	-1.894***	-0.019	2.056***	1.157**	1.094**
	Non-Governmental	-1.12**	-0.545	0.295	1.092*	0.395	-0.371	1.457***	0.524	0.311	0.961***
Field of REDD+ expertise	National REDD-policy design	0.176	-0.773	0.077	-1.618*	-0.679	0.175	0.089	0.551	0.931*	1.057**
	International REDD+ policy design1	-0.681	-0.377	-0.29	2.337***	-0.253	-0.351	0.886*	0.246	0.573	0.057
	REDD+ project implementation,	-1.199***	0.765	-0.601	0.377	0.354	-0.142	0.861*	0.373	-0.525	-0.325
	Mainly theoretical REDD+ research	-0.594	-1.827**	1.01*	-0.579	0.114	-0.563	-0.032	0.651	-0.207	1.81***
Experience in REDD-related work	0-2	-0.719*	NA	0.277	NA	0.29	NA	0.772*	NA	0.49	NA
	2-4	-1.085**	NA	0.12	NA	-0.854*	NA	0.841*	NA	1.057**	NA
	4-6	0.046	NA	-0.894	NA	-0.374	NA	0.686	NA	0.406	NA
	6-8	0.903	NA	0.378	NA	0.002	NA	1.702*	NA	0.778	NA
	8-10	-0.955	NA	-2.205	NA	-1.405	NA	0.845	NA	-1.655	NA
	more than 10 years	-2.52**	NA	-1.887	NA	-1.92	NA	0.713	NA	1.313	NA

	Multiple regression model	**Risk 6**		**Risk 7**		**Risk 8**		**Risk 9**	
		Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2	Cluster 1	Cluster 2
Stakeholder characteristics	Independent binary variables:	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
Main REDD+ working region	International	-1.574***	-2.019***	-0.796	-2.419***	2.04***	1.211**	-1.26**	0.531
	Asia	-1.847***	-2.13**	-0.522	0.737	2.12***	1.42**	-0.705	-1.047
	Latin America	-0.679	-2.018***	0.601	0.536	1.361**	1.718***	0.601	-0.564
	Africa	-1.717***	-1.674**	-0.8	-1.674**	1.592**	1.676***	-0.467	-0.314
	Oceania	0.31	NA	0.41	NA	2.01	NA	-0.04	NA
Location of organization	Annex-1 country	-1.652***	-1.989***	-0.346	-1.301**	2.051***	1.849***	-0.765**	-0.201
	Non-Annex-1 country	-0.934**	-1.86***	-0.264	0.048	1.388***	0.917**	0.075	-0.422
Profession	Academia	-1.351***	-1.188	-0.614	-3.648***	1.567**	1.592**	0.461	0.552
	Business	-1.406**	-2.874***	0.072	0.166	2.006**	1.226*	0.083	0.626
	Governmental	-1.043**	-2.306***	-0.178	0.094	1.586***	1.756***	-0.79	-0.444
	Non-Governmental	-1.72***	-1.745***	-0.382	-0.734	2.111***	1.482***	-1.343**	-0.666
Field of REDD+ expertise	National REDD-policy design	-0.545	-0.107	-0.676	0.152	0.459	1.155**	0.171	-0.59
	International REDD+ policy design1	-0.705	-0.77	-0.939*	-2.034***	1.957***	0.203	-0.558	0.683
	REDD+ project implementation,	-0.807*	-1.587**	1.272**	0.765	0.677	0.454	-0.031	-0.676
	Mainly theoretical REDD+ research	-0.638	-0.385	0.031	-0.421	0.905	0.988*	-0.583	0.315
Experience in REDD-related work	0-2	-1.528***	NA	0.395	NA	0.636	NA	-0.61	NA
	2-4	-1.838***	NA	-1.443***	NA	2.773***	NA	0.425	NA
	4-6	-0.974	NA	0.146	NA	2.106**	NA	-1.154	NA
	6-8	-0.997	NA	-1.772*	NA	1.302	NA	-2.297**	NA
	8-10	-0.005	NA	2.195	NA	3.295**	NA	-0.105	NA
	more than 10 years	1.013	NA	1.18	NA	2.847**	NA	-0.753	NA

Note: * $p < 0.1$; ** $p < 0.05$; ***$p< 0.01$

Figure A: *Distribution of risk perception factors for each risk. Rating of the risk perception factor is displayed according to the color legend at the bottom of the figure. The number of ratings for each risk is displayed on the y-axis.*

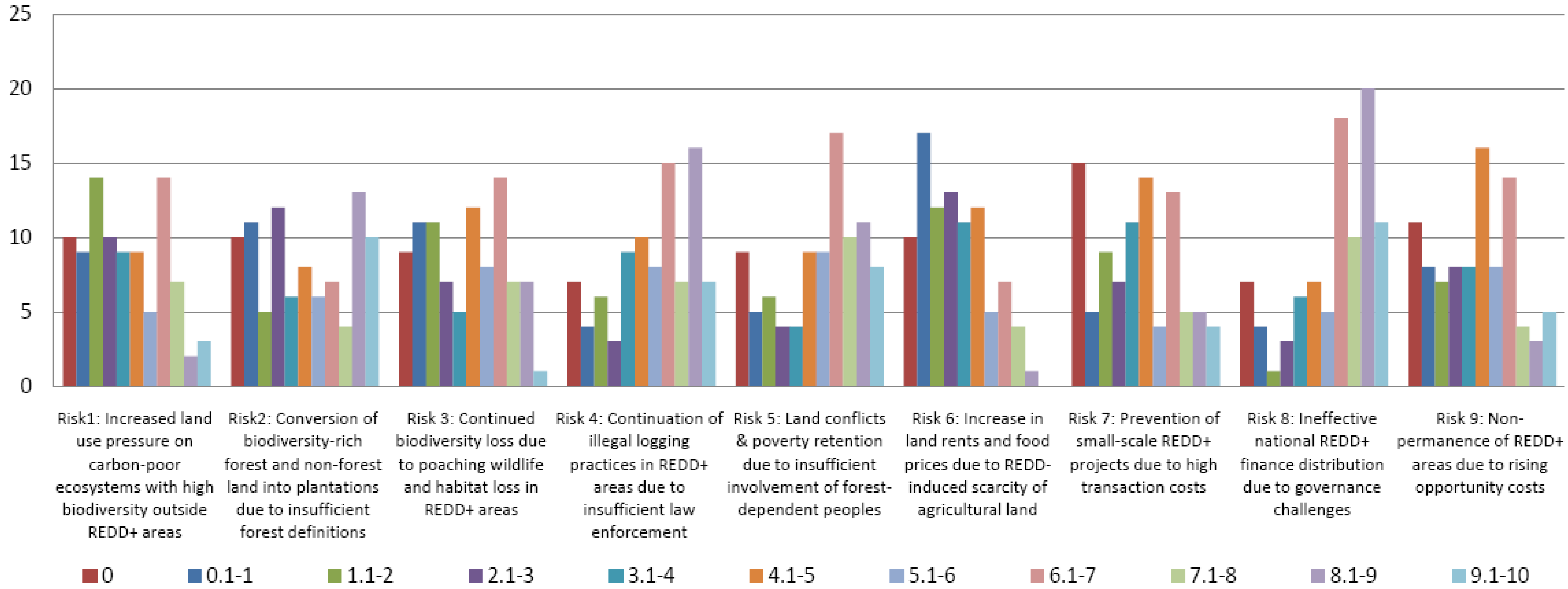

***Table B**: Perceived effectiveness rating of policy options to mitigate REDD+ implementation risks*

Risk	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Risk1: Increased land use pressure on carbon-poor ecosystems with high biodiversity outside REDD+ areas	Mandatory regulatory policy to protect biodiversity (e.g. UNFCCC standard)	Voluntary regulatory policy to protect biodiversity (e.g. national code of conduct)	Mandatory incentive policy to protect biodiversity (e.g. extra payment for biodiversity under REDD+ fund)	Voluntary incentive policy to protect biodiversity (e.g. added value via certification label)		
	5.74	**3.66**	**7.06**	**4.58**		
Risk2: Conversion of biodiversity-rich forest and non-forest land into plantations due to insufficient forest definitions	Maintenance of current UNFCCC/IPCC definitions	Exclusion of natural forest conversion under forest definitions	Exclusion of plantation forestry under the REDD scope	Policy measures to incentivize the protection of biodiversity		
	3.36	**6.63**	**7.03**	**6.29**		
Risk 3: Continued biodiversity loss due to poaching wildlife and habitat loss in REDD+ areas	Mandatory regulatory policy to protect biodiversity (e.g. UNFCCC standard)	Voluntary regulatory policy to protect biodiversity (e.g. national code of conduct)	Mandatory incentive policy to protect biodiversity (e.g. extra payment for biodiversity under REDD+ fund)	Voluntary incentive policy to protect biodiversity (e.g. added value via certification label)		
	5.57	**4.06**	**6.67**	**5.08**		
Risk 4: Continuation of illegal logging practices in REDD+ areas due to insufficient law enforcement	Mandatory governance regulations for REDD (e.g. international ban of illegal logging imports	Voluntary governance regulations for REDD (e.g. Forest Law Enforcement, Governance, and Trade = FLEGT)	Mandatory punishment system (e.g. debits/payments) for non-permanence or leakage	Voluntary incentives (e.g. payments) for sustainable development policies and measures (SDPAM)	Mandatory in-project risk reduction measures (e.g. buffer areas, insurance reserves) to account for non-permanence and leakage	
	6.73	**5.27**	**7.23**	**5.64**	**6.74**	

Risk 5: Land conflicts & poverty retention due to insufficient involvement of forest-dependent peoples	Mandatory governance control (e.g. independent third-party monitoring)	Voluntary governance control (e.g. national monitoring of policy implementation	Voluntary donor-financed REDD capacity-building to improve governance conditions (e.g. FLEGT)	Mandatory international REDD safeguards prior to implementation (prior informed consent, clearly defined ownership and use rights)	Voluntary REDD project safeguards (e.g. CCBA standards)	Mandatory national liability mechanism for dispute resolution (e.g. on transfers, ownership
	7.07	**4.50**	**5.76**	**7.30**	**5.45**	**6.64**
Risk 6: Increase in land rents and food prices due to REDD-induced scarcity of agricultural land	Mandatory regulatory policy against the conversion of subsistence agricultural land	Voluntary policy guidelines against the conversion of subsistence agricultural land	Mandatory national negative incentive policy (e.g. tax, penalty) against the conversion of subsistence agricultural land	National investment programs into agriculture intensification		
	5.78	**3.94**	**5.89**	**6.24**		
Risk 7: Prevention of small-scale REDD+ projects due to high transaction costs	Mandatory international regulatory policy to prefer small-scale REDD projects (e.g. in REDD fund regulations)	Voluntary international regulatory policy to prefer small-scale REDD projects	Simplified international rules and regulations for small-scale REDD projects (to lower the transaction costs)			
	5.23	**3.96**	**6.33**			
Risk 8: Ineffective national REDD+ finance distribution due to governance challenges	Direct REDD finance channeling from international to project level	REDD finance channeling via a national government focal point	Third-party verification of REDD finance transfer effectiveness	National government verification of REDD finance transfer effectiveness	Mandatory national liability mechanism for dispute resolution (e.g. on transfers, ownership)	
	6.00	**4.77**	**7.29**	**4.90**	**6.30**	

Risk 9: Non-permanence of REDD+ areas due to rising opportunity costs	Mandatory negative incentive (e.g. debits/payments) for non-permanence or leakage	In-project risk reduction measures (e.g. buffer areas, insurance reserves) to account for non-permanence and leakage	Adaptive incentive payment schemes (e.g. fund/market linked to change in opportunity costs)	Co-financing via mandatory incentive policy to protect biodiversity (e.g. extra payment for biodiversity under REDD+ fund)	Co-financing via voluntary incentive policy to protect biodiversity (e.g. added value via certification label)
	6.77	**6.44**	**6.23**	**6.62**	**5.27**

Mandatory regulatory policy

Voluntary regulatory policy

Mandatory incentive policy

Voluntary incentive policy

others

Table C: *ANOVA for the risk perception in relation to independent variables and their interactions*

		ANOVA - All Data						ANOVA - Cluster 1						ANOVA - Cluster 2					
Risk	**Variable group**	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**	
1	Profession	3	2.33	0.78	0.15	0.927		3	2.94	0.98	0.18	0.909		3	3.16	1.05	0.13	0.943	
	Working region	4	25.74	6.44	1.27	0.293		4	22.53	5.63	1.03	0.414		3	10.01	3.34	0.40	0.753	
	Expertise	3	4.41	1.47	0.29	0.832		3	2.82	0.94	0.17	0.914		3	4.92	1.64	0.20	0.896	
	Working region : Expertise	7	23.08	3.30	0.65	0.713		7	20.96	2.99	0.55	0.788		5	11.57	2.31	0.28	0.918	
	Profession : Working region	10	20.67	2.07	0.41	0.937		10	26.24	2.62	0.48	0.884		4	4.43	1.11	0.13	0.968	
	Profession : Expertise	8	16.71	2.09	0.41	0.909		6	11.22	1.87	0.34	0.906		1	0.61	0.61	0.07	0.790	
	Residuals	56	283.99	5.07				21	114.56	5.46				17	140.91	8.29			
2	Profession	3	35.04	11.68	2.49	0.069	.	3	9.50	3.17	0.94	0.440		3	26.35	8.78	1.21	0.336	
	Working region	4	22.89	5.72	1.22	0.312		4	23.52	5.88	1.74	0.178		3	7.66	2.55	0.35	0.788	
	Expertise	3	44.79	14.93	3.19	0.031	*	3	13.43	4.48	1.33	0.293		3	47.60	15.87	2.19	0.127	
	Working region : Expertise	7	37.87	5.41	1.15	0.344		7	35.17	5.02	1.49	0.225		5	36.52	7.30	1.01	0.443	
	Profession : Working region	10	66.88	6.69	1.43	0.193		10	64.17	6.42	1.90	0.103		4	31.98	8.00	1.10	0.387	
	Profession : Expertise	8	50.07	6.26	1.34	0.246		6	22.13	3.69	1.09	0.399		1	0.07	0.07	0.01	0.922	
	Residuals	56	262.50	4.69				21	70.87	3.38				17	123.25	7.25			
3	Profession	3	8.21	2.74	0.93	0.430		3	25.77	8.59	2.79	0.065	.	3	30.83	10.28	3.57	0.036	*
	Working region	4	13.52	3.38	1.15	0.341		4	13.82	3.46	1.12	0.372		3	14.02	4.67	1.62	0.221	
	Expertise	3	7.56	2.52	0.86	0.467		3	8.54	2.85	0.93	0.446		3	9.76	3.25	1.13	0.365	
	Working region : Expertise	7	21.69	3.10	1.06	0.403		7	27.82	3.97	1.29	0.302		5	5.45	1.09	0.38	0.856	
	Profession : Working region	10	62.76	6.28	2.14	0.036	*	10	33.59	3.36	1.09	0.411		4	5.86	1.47	0.51	0.730	
	Profession : Expertise	8	57.81	7.23	2.47	0.023	*	6	45.78	7.63	2.48	0.057	.	1	0.52	0.52	0.18	0.676	
	Residuals	56	164.07	2.93				21	64.57	3.08				17	48.98	2.88			

		ANOVA - All Data						ANOVA - Cluster 1						ANOVA - Cluster 2					
Risk	**Variable group**	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**	
4	Profession	3	5.53	1.84	0.69	0.562		3	22.36	7.45	4.47	0.014	*	3	15.90	5.30	1.65	0.216	
	Working region	4	39.07	9.77	3.66	0.010	*	4	42.02	10.51	6.30	0.002	**	3	17.17	5.72	1.78	0.190	
	Expertise	3	5.39	1.80	0.67	0.572		3	7.70	2.57	1.54	0.234		3	11.95	3.98	1.24	0.327	
	Working region : Expertise	7	13.66	1.95	0.73	0.647		7	25.14	3.59	2.15	0.082	.	5	9.29	1.86	0.58	0.717	
	Profession : Working region	10	77.47	7.75	2.90	0.005	**	10	55.08	5.51	3.30	0.010	*	4	2.34	0.59	0.18	0.945	
	Profession : Expertise	8	25.56	3.19	1.20	0.318		6	15.00	2.50	1.50	0.226		1	1.18	1.18	0.37	0.554	
	Residuals	56	149.47	2.67				21	35.01	1.67				17	54.74	3.22			
5	Profession	3	3.00	1.00	0.30	0.825		3	6.32	2.11	0.33	0.806		3	1.65	0.55	0.46	0.714	
	Working region	4	5.78	1.45	0.43	0.784		4	5.12	1.28	0.20	0.937		3	13.94	4.65	3.89	0.028	*
	Expertise	3	11.84	3.95	1.18	0.324		3	12.32	4.11	0.64	0.601		3	8.14	2.71	2.27	0.117	
	Working region : Expertise	7	35.17	5.02	1.51	0.184		7	27.51	3.93	0.61	0.743		5	21.25	4.25	3.56	0.022	*
	Profession : Working region	10	69.75	6.98	2.09	0.040	*	10	38.86	3.89	0.60	0.795		4	3.26	0.81	0.68	0.614	
	Profession : Expertise	8	5.75	0.72	0.22	0.987		6	18.46	3.08	0.48	0.818		1	0.60	0.60	0.50	0.488	
	Residuals	56	186.61	3.33				21	135.67	6.46				17	20.31	1.19			
6	Profession	3	4.42	1.47	0.36	0.785		3	3.41	1.14	0.34	0.794		3	8.99	3.00	0.50	0.689	
	Working region	4	14.91	3.73	0.90	0.469		4	18.09	4.52	1.37	0.279		3	1.73	0.58	0.10	0.961	
	Expertise	3	9.36	3.12	0.76	0.524		3	7.75	2.58	0.78	0.518		3	6.93	2.31	0.38	0.766	
	Working region : Expertise	7	23.03	3.29	0.80	0.594		7	21.15	3.02	0.91	0.516		5	8.68	1.74	0.29	0.913	
	Profession : Working region	10	30.58	3.06	0.74	0.684		10	30.20	3.02	0.91	0.540		4	26.50	6.62	1.10	0.388	
	Profession : Expertise	8	17.06	2.13	0.52	0.840		6	17.73	2.95	0.89	0.518		1	0.13	0.13	0.02	0.886	
	Residuals	56	231.43	4.13				21	69.51	3.31				17	102.28	6.02			

		ANOVA - All Data						ANOVA - Cluster 1						ANOVA - Cluster 2					
Risk	**Variable group**	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**		**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**	
7	Profession	3	24.23	8.08	2.07	0.114		3	3.15	1.05	0.30	0.826		3	51.67	17.22	4.81	0.013	*
	Working region	4	67.20	16.80	4.31	0.004	**	4	20.09	5.02	1.42	0.260		3	68.20	22.73	6.35	0.004	**
	Expertise	3	69.96	23.32	5.98	0.001	**	3	58.46	19.49	5.53	0.006	**	3	7.20	2.40	0.67	0.582	
	Working region : Expertise	7	27.26	3.89	1.00	0.442		7	47.81	6.83	1.94	0.114		5	15.57	3.11	0.87	0.521	
	Profession : Working region	10	35.94	3.59	0.92	0.520		10	37.46	3.75	1.06	0.430		4	17.63	4.41	1.23	0.335	
	Profession : Expertise	8	41.59	5.20	1.33	0.247		6	16.04	2.67	0.76	0.610		1	0.54	0.54	0.15	0.701	
	Residuals	56	218.34	3.90				21	74.01	3.52				17	60.82	3.58			
8	Profession	3	0.41	0.14	0.03	0.992		3	3.24	1.08	0.16	0.919		3	0.93	0.31	0.11	0.953	
	Working region	4	2.29	0.57	0.13	0.969		4	5.87	1.47	0.22	0.922		3	4.87	1.62	0.57	0.641	
	Expertise	3	12.48	4.16	0.98	0.410		3	26.53	8.84	1.35	0.286		3	4.40	1.47	0.52	0.677	
	Working region : Expertise	7	25.79	3.68	0.87	0.540		7	45.65	6.52	0.99	0.462		5	11.13	2.23	0.78	0.575	
	Profession : Working region	10	57.56	5.76	1.35	0.227		10	51.69	5.17	0.79	0.640		4	6.87	1.72	0.60	0.665	
	Profession : Expertise	8	39.96	5.00	1.17	0.332		6	25.31	4.22	0.64	0.695		1	3.23	3.23	1.14	0.301	
	Residuals	56	238.53	4.26				21	137.65	6.56				17	48.27	2.84			
9	Profession	3	33.95	11.32	2.51	0.068	.	3	28.11	9.37	4.18	0.018	*	3	10.61	3.54	0.51	0.682	
	Working region	4	9.70	2.43	0.54	0.709		4	28.98	7.24	3.23	0.033	*	3	13.19	4.40	0.63	0.604	
	Expertise	3	5.97	1.99	0.44	0.725		3	13.82	4.61	2.05	0.137		3	3.77	1.26	0.18	0.908	
	Working region : Expertise	7	15.83	2.26	0.50	0.830		7	14.08	2.01	0.90	0.527		5	16.64	3.33	0.48	0.787	
	Profession : Working region	10	75.35	7.54	1.67	0.111		10	78.62	7.86	3.50	0.007	**	4	20.73	5.18	0.75	0.574	
	Profession : Expertise	8	26.81	3.35	0.74	0.654		6	20.89	3.48	1.55	0.210		1	5.09	5.09	0.73	0.404	
	Residuals	56	252.64	4.51				21	47.11	2.24				17	118.20	6.95			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table D: *Tukey-Test results for the ANOVA (with interactions)*

Risk	all data	diff	lwr	upr	p adj
2	NGO-Business	1.769866	-0.13806	3.677791	0.078871
4	LatinAmerica-regional-Africa-regional	-1.57757	-3.04269	-0.11246	0.028384*
	LatinAmerica-regional-International	-1.40067	-2.83234	0.030991	0.058225
	Business:Asia-regional-Academia:Asia-regional	7.076137	-0.24515	14.39742	0.07008
	Business:LatinAmerica-regional-Business:Asia-regional	-6.60931	-13.2927	0.074083	0.056006
	Business:LatinAmerica-regional-Business:International	-3.63826	-7.49692	0.220392	0.088102
7	LatinAmerica-regional-Africa-regional	1.705661	0.091323	3.319999	0.033069*
	LatinAmerica-regional-International	2.135256	0.557773	3.712738	0.002725**
	Policy+Implementation-Policy	1.854991	0.635111	3.074871	0.000821***
9	NGO-Academia	-1.42379	-2.99963	0.152039	0.091143

Table D: *Tukey-Test results for the ANOVA (with interactions)*

Risk	cluster 1	diff	lwr	upr	p adj
2	Business:International-NGO:Asia-regional	-4.87664	-10.0756	0.322284	0.086871
	NGO:LatinAmerica-regional-NGO:Asia-regional	-5.13894	-10.6968	0.418945	0.097405
	Governmental:Oceania-regional-NGO:Asia-regional	-7.50209	-15.3621	0.357942	0.075288

4	Governmental-Business	-1.59163	-3.17837	-0.0049	0.04906*
	NGO-Governmental	1.476335	0.058169	2.894501	0.038731*
4	LatinAmerica-regional-Africa-regional	-1.79485	-3.38428	-0.20543	0.020411*
	International-Asia-regional	1.603454	-0.011	3.217909	0.052306
	LatinAmerica-regional-International	-2.02765	-3.55269	-0.5026	0.004499**
	Business:LatinAmerica-regional-NGO:Africa-regional	-4.17541	-8.34675	-0.00407	0.049554*
	Governmental:LatinAmerica-regional-NGO:Africa-regional	-3.65119	-7.5131	0.210722	0.081463
	Business:Asia-regional-Academia:Asia-regional	7.17306	0.484034	13.86209	0.025207*
	Business:International-Academia:Asia-regional	4.385589	-0.34427	9.115445	0.095284
	Governmental:Asia-regional-Business:Asia-regional	-6.0452	-11.9444	-0.14603	0.039731*
	NGO:Asia-regional-Business:Asia-regional	-5.94354	-12.25	0.362938	0.083601
	Business:LatinAmerica-regional-Business:Asia-regional	-7.02731	-13.3338	-0.72083	0.016674*
	Governmental:LatinAmerica-regional-Business:Asia-regional	-6.50309	-12.6093	-0.39687	0.027074*
	Governmental:Oceania-regional-Business:Asia-regional	-7.49301	-15.2168	0.230812	0.065543
	Business:International-Governmental:Asia-regional	3.257727	-0.2677	6.783153	0.097865
	Business:LatinAmerica-regional-Business:International	-4.23984	-8.41118	-0.0685	0.042952*
	Governmental:LatinAmerica-regional-Business:International	-3.71562	-7.57753	0.146292	0.070372
7	Policy+Implementation-Policy	2.130359	0.495231	3.765487	0.006563**
9	NGO-Academia	-1.80433	-3.38148	-0.22718	0.019801*
	LatinAmerica-regional-International	1.908212	0.234709	3.581714	0.018851*
	NGO:Africa-regional-Academia:Africa-regional	-3.74082	-7.76119	0.279558	0.09268

Table D: *Tukey-Test results for the ANOVA (with interactions)*

Risk	cluster 2	diff	lwr	Upr	p adj
3	Governmental-Business	-3.11975	-5.65223	-0.58727	0.012134*
5	LatinAmerica-regional-Asia-regional	-1.30177	-2.77896	0.175414	0.097285
	LatinAmerica-regional:Policy+Implementation-International:Policy+Implementation	-3.50296	-6.57757	-0.42836	0.015861*
	Africa-regional:Research-LatinAmerica-regional:Policy+Implementation	4.113333	0.438478	7.788189	0.018774*
7	Business-Academia	3.814	0.337917	7.290083	0.028046*
	Governmental-Academia	3.74175	0.608451	6.875049	0.015396*
	NGO-Academia	2.91379	0.151279	5.6763	0.036217*
	LatinAmerica-regional-Africa-regional	2.4717	0.070251	4.87315	0.042133*
	LatinAmerica-regional-International	3.008117	0.606668	5.409567	0.010634*
	NGO:LatinAmerica-regional-Academia:International	5.952762	-0.14211	12.04764	0.060134

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1