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# Climate Change, Adaptation, and Formal Education: the Role of Schooling for Increasing Societies' Adaptive Capacities in El Salvador and Brazil

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**ABSTRACT.** With a worldwide increase in disasters, the effects of climate change are already being felt, and it is the urban poor in developing countries who are most at risk. There is an urgent need to better understand the factors that determine people's capacity to cope with and adapt to adverse climate conditions. This paper examines the influence of formal education in determining the adaptive capacity of the residents of two low-income settlements: Los Manantiales in San Salvador (El Salvador) and Rocinha in Rio de Janeiro (Brazil), where climate-related disasters are recurrent. In both case study areas, it was found that the average levels of education were lower for households living at high risk, as opposed to residents of lower risk areas. In this context, the influence of people's level of education was identified to be twofold due to (a) its direct effect on aspects that reduce risk, and (b) its mitigating effect on aspects that increase risk. The results further suggest that education plays a more determinant role for women than for men in relation to their capacity to adapt. In light of these results, the limited effectiveness of institutional support identified by this study might also relate to the fact that the role of formal education has so far not been sufficiently explored. Promoting (improved access to and quality of) formal education as a way to increase people's adaptive capacity is further supported with respect to the negative effects of disasters on people's level of education, which in turn reduce their adaptive capacity, resulting in a vicious circle of increasing risk.

**Key Words:** *adaptation; adaptive capacity; Brazil; climate change; coping capacity; disaster; education; El Salvador; flood; income; informal settlement; landslide; risk reduction*

## INTRODUCTION

Today, climate change is on everyone's lips. With the global temperature on the rise and a worldwide increase in so-called natural disasters, the effects of climate change are already being felt, and many of the current climate-change studies predict a continued rise in the frequency of such events, including windstorms, heat waves, heavy rains, floods, and landslides (Intergovernmental Panel on Climate Change (IPCC) 2007). Each year, disasters trigger devastating losses in human lives and economic assets, with the poor in developing countries being most at risk (United Nations International Strategy for Disaster Reduction (UNISDR) 2002, Wisner et al. 2004).

With rapid urbanization, which increasingly exposes populations and economies to climate-related hazards, the trend is for the risk to become urban (IPCC 2007). In Latin America and the Caribbean, 89% of the population is predicted to live in cities by 2050 (United Nations 2009). The urban poor, often living in informal settlements, on steep slopes, or on flood plains, are particularly vulnerable (e.g., Bigio 2003, IPCC 2007, Wamsler 2009, Wisner et al. 2004).

Although considerable research has been conducted on many aspects related to the geological and biological impacts of climate change, little is known about the specific impacts on the future well-being of the world's population and how they

are related to our ability to adapt to changing climate conditions. In fact, knowledge about future societies' adaptive capacities is one of the most important missing links in making predictions about the effects of climate change (Lutz 2008).

Against this background, this paper's objective is to help fill this gap by providing new knowledge on the aspects that shape people's capacities to adapt to changing climate conditions. More specifically, it aims to examine how the risk and adaptive capacity of the residents of two low-income settlements (*Los Manantiales* in San Salvador (El Salvador) and *Rocinha* in Rio de Janeiro (Brazil)) are influenced by their level of formal education. In addition, it analyzes the complex reality of people living in disaster-prone informal settlements or so-called "slums," thus illustrating how their precarious living conditions and social marginalization are interlinked and, in turn, related to their level of formal education. The motivation for focusing on formal education is based on recent studies that hypothesize that educational attainment may enhance people's ability to cope with disasters (e.g., Adger et al. 2004, Toya and Skidmore 2005, Blankespoor et al. 2010). This study is not based on the hypothesis that formal education is the only or the most important driver, but on the need for better understanding of the influence of formal education on people's level of risk. Formal education refers here to studies at the primary, secondary, and university levels.

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After a description of the research methodology (second section), the third section presents the conceptual framework on which this study is based. The interrelations among the central concepts of disaster, risk, and adaptive capacity are identified and viewed from a holistic systems perspective of risk reduction and climate-change adaptation. Links with formal education are also highlighted. The fourth section presents the research results from the conducted quantitative and qualitative analyses. The similarities, differences, and gaps among the results from the two case-study areas (in El Salvador and Brazil) are compared and interpreted in the “Results” section. The conclusions are presented in the final section.

## METHODOLOGY

This paper is based on a comparative analysis of two case studies that examine the influence of formal education in determining the adaptive capacity of residents of informal low-income settlements where climate-related disasters are recurrent. Both case studies were motivated by the project on “Forecasting Societies’ Adaptive Capacities to Climate Change,” funded by the European Research Council and coordinated at the International Institute for Applied Systems Analysis (IIASA) (Lutz 2008).

The first case study was carried out in different phases between 2006 and 2011 and focuses on the community *Los Manantiales* in San Salvador, El Salvador, where flooding and landslides are the main hazards to life and livelihoods, followed by windstorms and earthquakes. Additional analyses were conducted in two other San Salvadorian communities: *José Cecilio del Valle* and *Divina Providencia*. The second case study was carried out between 2009 and 2011 in *Laboriaux* and *Cachopa*, two communities of *Rocinha*, an informal settlement in central Rio de Janeiro, Brazil, where landslides and floods are recurrent.

In both case studies, hereafter referred to as the San Salvador and the Rio case studies, data were collected through semi-structured and focused interviews, surveys, literature review, and observation, and both statistical and qualitative data analyses were applied. The statistical analyses investigate how formal education influences people’s level of risk, their coping strategies, and the institutional support received. The qualitative analyses focus on exploring direct and secondary effects that education may have on disaster occurrence, and vice versa.

The semi-structured interviews were mainly conducted during 2009–2011 and included 118 households in San Salvador and 94 households in Rio. Among these, those households most at risk (i.e., the focus group) and those households at lower risk (i.e., the control group) were identified by local censuses and post-disaster evaluations conducted by national authorities and aid organizations working within the

respective communities. In El Salvador, related data were collected in 2005 after a disaster season characterized by a tragic combination of Hurricane Stan, floods, landslides, small-scale earthquakes, and the eruption of the Ilamatepec volcano. In Rio, related data were updated after the 2010 landslides in *Rocinha*. The selection of the interviewees was based on random sampling, among other things, with the help of maps and numeration of households. Given the dangerous study environment, the sampling procedure was sometimes difficult, in practice, to follow rigorously.

In addition to the household interviews, around 90 focused interviews were held at different levels, including with international and national risk management experts, staff from organizations working in the case-study areas, community leaders, and other key informants. Observation was of great importance to explore direct and secondary effects that education may have on disaster occurrence, and vice versa, and for crosschecking information from other sources. For this purpose, the authors of this study stayed several months in the respective study areas. In the context of the San Salvador case study, institutional databases were also accessed and analyzed, and data were drawn from previous research conducted during 2006. For the literature review, more than 200 publications were consulted. Finally, the two case studies were followed by desk work in 2011 to assess the different outcomes.

For the qualitative data analyses, a combination of literal reading, grounded theory (Glaser and Strauss 1967), systems analysis (Sternan 2000), and cultural theory (Thompson et al. 1990) was applied. For the statistical analyses of the data obtained from the two case studies, so-called cross-tabulations were conducted to identify potential relationships between different attributes, and their significance was tested using  $\chi^2$  (Chi square) tests.

Based on the research objectives, the attributes selected to be analyzed (in qualitative and quantitative terms) were:

- People’s level of formal education;
- People’s level of income;
- People’s level of risk;
- Impact from past disasters (i.e., people’s previous disaster experience);
- Local strategies used to cope with risk or disasters (i.e., people’s so-called coping strategies);
- The institutional support received to reduce and adapt to disaster risk; and
- Other possible key factors or attributes.

Related data were obtained from the above-mentioned databases and interviews. Household members living in the case-study areas were, for instance, asked if they consider

themselves to be at risk; if they believe themselves to be at higher or lower risk compared with other community members; how their risk situation has changed over the past; if they have been subject to specific disaster events; how they cope with the risk and dangers associated with living in the community; if they can name related measures they (or others) undertake; if they receive outside assistance; and how past disasters have affected their everyday life (such as income and education).

In addition to cross-tabulations, a linear regression analysis was carried out to identify any relationship between educational level and level of income, and two log-linear analyses were made to examine the interaction between three independent variables (namely, people's previous experience with disasters, their income, and risk reduction measures taken). Moreover, *t*-tests were applied to assess if the averages of education of the focus and control groups are significantly different from each other.

For the San Salvador and the Rio case studies, a total of 31 and 80 quantitative tests, respectively, were made. First, results that were individually statistically significant with a 5% confidence level were identified. In the following, a Bonferroni-type adjustment was performed to adjust the confidence level because the error probability increases with the number of tests conducted. In the following text, probabilities (before and after Bonferroni-type adjustment) are indicated after each result where appropriate (e.g.,  $p < 0.003$ , adjusted  $p < 0.16$ ). In some cases, results with lower probability are included in order to highlight findings that are considered to be crucial to follow up in future studies.

To obtain a good approximation of "reality," and thus reliability, and to deal with threats to the validity of the conclusions, such as bias in the selection of cases or focus areas and self-reported bias by the interviewees, different types of triangulation were used. These include data, methodological, theoretical, and investigator triangulation (cf. Harvey and MacDonald 1993, Flick 2006). Remaining limitations are mainly due to the methods chosen for statistical analysis, differences in the context and approaches used for the two case studies, lack of historical data, and the very difficult access to existing data in the precarious and insecure study areas.

#### **ADAPTATION AND EDUCATION: A CONCEPTUAL FRAMEWORK**

Disasters are commonly seen as the result of an interaction between hazards (*H*) and vulnerable conditions (*V*). In other words, it is understood that hazards such as floods, landslides, and windstorms do not cause disasters on their own. It is only when they are combined with vulnerable conditions, such as people or systems susceptible to the damaging effects of these hazardous events, that disasters occur; i.e., "a serious

disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR 2009:9).

On this basis, disaster risk is conventionally expressed in the following pseudo-equation:

$$R = H \cdot V \quad (1)$$

where *R* stands for risk, *H* for hazard(s) and *V* for vulnerability.

Whereas a disaster is said to be the result of "insufficient capacity or measures to reduce or cope with potential negative consequences" (UNISDR 2009:9), the definition of disaster risk (as represented by Eq. [1]) does not include such capacities and/or measures and, consequently, does not link the components of risk to appropriate risk-reduction measures. In addition, actions related to recovery are often not mentioned as an inherent part of risk reduction. However, preparedness for recovery is crucial for risk reduction because (a) both spontaneous and planned early recovery start the moment a hazard occurs; (b) risk areas affected by a hazard are generally still in the process of recovering from earlier hazards; (c) the term "hazard" includes primary and secondary hazards (e.g., landslides or cholera after earthquakes and floods) and includes not only rapid but also slow-onset events that can develop over time or are successive (e.g., aftershocks) (Wamsler, *unpublished manuscript*).

The identified limitations led to the development of the extended definition of risk and risk reduction by Wamsler (2009), which directly links the different risk components to the corresponding risk-reduction measures. These include not only measures of prevention (to reduce or avoid hazards), mitigation (to reduce vulnerability), and preparedness to respond (to improve post-disaster response), but also measures of preparedness to recover (to improve post-disaster recovery). This can be expressed by:

$$R = H/P \cdot V/M \cdot LR/PP \quad (2)$$

where *R* stands for risk, *H* for hazard(s), *V* for vulnerability,  $L_R$  for lack of mechanisms and structures to respond and recover, *P* for prevention, *M* for mitigation, and *PP* for preparedness for response and recovery.

The development of the extended risk definition has both theoretical and practical implications because the way risk is

defined dictates how risk reduction is addressed (Slovic 1999). The four risk-reduction measures included are: (a) prevention (or hazard reduction), which aims (to increase the capacity) to avoid or reduce the potential intensity and frequency of existing or likely future hazards that threaten households, communities, and/or institutions; (b) mitigation, which aims (to increase the capacity) to minimize the existing or likely future vulnerability of households, communities, and/or institutions to potential hazards/disasters; (c) preparedness for response, which aims (to increase the capacity) to establish effective response mechanisms and structures for households, communities, and/or institutions so that they can react effectively during and in the immediate aftermath of potential future hazards/disasters; and (d) preparedness for recovery, which aims (to increase the capacity) to ensure appropriate recovery mechanisms and structures for households, communities, and/or institutions that are accessible after a potential hazard/disaster (including risk transfer and sharing). The measures are thus defined in a way to highlight that, for each type of measure, there are always two different ways to assist people in coping with or adapting to changing climate conditions. These are (a) directly reducing the corresponding risk component or (b) increasing capacities to reduce the corresponding risk component, thus enabling societies to reduce their level of risk on their own. In both cases, the active participation of institutions and people at risk and the building on local patterns of behavior and existing coping strategies proved to be crucial for achieving sustainable change (Wamsler 2007). The latter includes evaluating the local strategies for reducing risk, supporting and improving effective ones, scaling back unsustainable practices and, where necessary, offering better alternatives.

Coping capacity is defined by UNISDR (2009:8) as “(t)he ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.” It includes already used coping capacities (i.e., existing coping strategies) as well as potential, but so far unused, coping capacities. The “skills and resources” mentioned in the definition can be translated into the four risk-reduction measures of Eq. [2], which would mean that a system’s (or people’s) coping capacity is its (their) ability to reduce overall risk by applying these measures. Although the term “adaptive capacity” is not included in UNISDR’s glossary (2009), a definition can be found in the introduction to the IPCC’s Fourth Assessment Report, stating that “adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” (IPCC 2007:21). Using the extended definition of risk described above, it can thus be assumed that people’s adaptive capacity and people’s coping capacity are determined by the same attributes or factors. Adaptive capacity and coping capacity

are, therefore, used as synonyms in this study, as well as the associated process of increasing these capacities, namely, risk reduction and climate-change adaptation.

Against this background, what are the key factors to people’s capacity to cope with and adapt to increasing disasters? Income is often considered as “the” (or one of the) key factor(s) (e.g., Cutter et al. 2003, Lindell and Perry 2004, Wisner et al. 2004, Kahn 2005, Toya and Skidmore 2005, Blankespoor et al. 2010, United Nations Human Settlement Programme (UN-HABITAT) 2010). It is argued that people who have resources (e.g., wealth, assets, insurance) are more likely to succeed in safeguarding their lives, property, and livelihoods as well as to make a swifter recovery after disasters, although their economic losses in disasters are often of greater magnitude in absolute numbers (Wisner et al. 2004). In contrast, formal education is generally not considered to be a key factor to people’s level of risk or their capacity to cope with and adapt to disasters—it is rather only linked to a higher socioeconomic status and more lifetime earnings (e.g., Cutter et al. 2003) or mentioned as one of many resources that people draw on to obtain a livelihood (see models such as the Pressure and Release (PAR) Model and the “Sustainable Livelihoods (SL) approach”) (Wisner et al. 2004). In other words, it is argued that it is only through its correlation with income (and livelihood) that education is related to risk.

In recent studies, however, the question is raised as to whether formal education might in fact play a more central role in determining people’s adaptive capacity. Combining different indicators of education with data from the OFDA/CRED International Disaster Database, three studies are able to demonstrate how a lower level of formal education, independent of income, is correlated with increasing numbers of deaths or other forms of loss from disasters. Adger et al. (2004:101) conclude that education exhibits “a strong (negative) relationship with mortality from climate related disasters.” Among the education proxies, the strongest indicator is the literacy rate among citizens aged 15–24, followed by the literacy rate among all citizens over 15, and the female to male literacy ratio. Toya and Skidmore (2005) use data on the total years of schooling attainment for the population aged 15 or more, and are able to demonstrate that countries with a greater number of years of schooling suffer fewer disaster-related deaths as well as damages per GDP. The correlation is particularly strong for developing countries for which the level of formal education proves more significant to disaster losses than for income levels. Using the female educational enrolment rate as an indicator, Blankespoor et al. (2010) establish that countries that invest in female education suffer fewer disaster-related deaths. Summarized, these studies are a strong indicator that formal education, as well as gender equality in education, seems to play a more important role in determining people’s level of risk than has been

**Table 1.** Average education and income levels in focus and control groups (i.e., people living in high-risk and lower-risk areas) based on recent surveys

Case study	Risk	Average education of head of household (years)	Average education of household members (years)	Average income of head of household (US\$ / BRL)	Total income of household (US\$ / BRL)	Household income per person (US\$ / BRL)
San Salvador	High	5.0	<sup>†</sup> 6.2	111	243	57
	Low	5.7	<sup>‡</sup> 7.0	71	259	59
Rio	High	5.6	6.5	818	1258	442
				(≈US\$ 485)	(≈US\$ 746)	(≈US\$ 262)
	Low	7.0	7.1	801	1478	568
				(≈US\$ 475)	(≈US\$ 876)	(≈US\$ 278)

<sup>†</sup> If only those who receive income are included, the average is 6.5.

<sup>‡</sup> If only those who receive income are included, the average is 7.3.

previously considered. They focus on different aspects related to education and risk, but lack a more comprehensive analysis of the importance of education vs. the different components that shape people’s level of risk (which is provided by this study).

## RESULTS: RISK TO CLIMATE-RELATED DISASTERS

The conceptual framework presented directly links to the research objectives of this study, which seek to analyze the role of formal education regarding (a) people’s level of risk, (b) their coping strategies, and (c) the institutional support they receive. According to the extended view of risk, both local coping strategies and institutional support are part of the factors that determine people’s level of risk (see Eq. [2]) and hence, the second and the third research objectives are in fact part of the first research objective. The difference in the factors that influence people’s level of risk can also be called differential vulnerability.

### Quantitative Analysis of Risk Factors—Differential Vulnerability

This section presents the results of the quantitative analyses of the factors that influence people’s differential vulnerability, and more specifically of the relative importance of education as opposed to other factors, such as income. The analyses include:

- A general comparison of the average levels of education and income in the high- and low-risk areas (the significance of which is determined using *t*-tests).
- Statistical tests to establish whether there is a direct relationship between level of education and level of income in the studied areas (using cross-tabulations,  $\chi^2$  tests, and a linear regression).
- A statistical analysis of the factors (including formal education and income) that determine people’s level of risk (using cross-tabulations and  $\chi^2$  tests).

The following four data sets formed the basis of these analyses:

- Survey data from the San Salvador case study (carried out in 2009–2010);
- Survey data from the Rio case study (carried out in 2010–2011);
- Institutional database of the low-income settlement *Los Manantiales* in San Salvador;
- Institutional database of the low-income settlement *Divina Providencia* in San Salvador. (*Divina Providencia* forms part of the San Salvador case study and was included in the survey from 2009–2010 (cf. “Adaptation and Education: a Conceptual Framework” above)).

### Average levels of education and income in high- and low-risk areas

The analysis of all four data sets indicates lower levels of education for households living at high risk as opposed to residents of lower risk areas. In other words, a correlation was identified between people’s level of education and people’s level of risk (see Tables 1 and 2). As opposed to the analyses of the average levels of education, the analysis of the average levels of income of the four data sets does not show a clear tendency and, thus, no clear correlation could be identified between people’s levels of income and people’s level of risk.

### Relationship between education and income

To explore the relationship between education and income, a series of cross-tabulations,  $\chi^2$  tests, and a linear regression analysis were conducted. The San Salvador survey shows no relationship between income and education. However, the 2003 database of *Los Manantiales* shows a significant correlation between (a) the average educational level of those over 18 years of age and total household income ( $p < 0.001$ ; adjusted  $p < 0.05$ ), and (b) total household income and the

**Table 2.** Average education and income levels in focus and control groups (i.e., people living in high-risk and lower-risk areas) based on analyses of institutional databases

Risk	Average education of head of household (years)	Average education of household members (years)	Average income of head of household (US\$)	Total income of household (US\$)	Household income per person (US\$)
San Salvador Manantiales (2003)					
High	5.0	5.8	181	269	60
Low	5.8	6.3	171	288	74
San Salvador Divina Providencia					
High	2.1	3.0	64	143	39
Low	4.4	5.0	86	92	49

educational level of the head of the household ( $p < 0.002$ ; adjusted  $p < 0.10$ ). The database of *Divina Providencia* did not allow similar analyses.

In the Rio case-study area, the cross-tabulation and  $\chi^2$  tests did not show any significant correlation between education and income at the household level. However, for the female residents, a significant correlation was identified between their level of education and income ( $p < 0.003$ ; adjusted  $p < 0.16$ ). No such correlation could be found for men. In other words, in the study area and only for women, it is likely that a higher educational level leads to a higher income. Although a similar analysis was not possible in the context of the San Salvador case study, the data analysis shows that the two most educated women (13 grades or higher) have a higher average income (i.e., US\$325) than men at the same educational level (i.e., US\$207). In addition, the least-educated women earn, on average, considerably less than the least-educated men.

#### *Factors that shape people's level of risk*

To investigate the factors that influence people's level of risk, education and income levels were analyzed in regard to the following attributes:

- Living in a (declared) risk area;
- People's own risk evaluation (i.e., people reporting to be at high risk);
- Impacts from past disasters;
- The use (and number) of coping strategies;
- Knowledge of existing risk factors; and
- Institutional support received.

#### *Factors influencing risk and past disaster impact*

Cross-tabulation and  $\chi^2$  analyses were applied to identify a possible correlation between educational and income levels on the one hand and living in a (declared) risk area, reporting to be at high risk, and impacts from past disasters on the other hand.

Importantly, the analysis of the 2003 database of *Los Manantiales* shows a negative correlation between the educational level of the heads of household and disaster risk (based on the households' own evaluation) ( $p < 0.015$ ; adjusted  $p < 0.10$ ). Apart from this result, educational and income levels were not found to be significantly correlated with disaster risk or impact from past disasters. However, in Rio, the data pointed toward a possible correlation between a lower mean educational level of households and living in a high-risk area (i.e., in *Laboriaux*) ( $p < 0.005$ , adjusted  $p < 0.4$ ). In addition, in the San Salvador case study, a clear correlation could be found between the way in which households were affected by Hurricane Mitch in 1998 and the way in which the same households were affected by Hurricane Stan in 2005 ( $p < 0.001$ ; adjusted  $p < 0.05$ ). No such analysis could be made for the Rio case study.

#### Factors influencing people's way of coping

To assess if people's use of coping strategies is influenced by their level of education, income, and/or past disaster impacts, cross-tabulations were performed using these variables.

The San Salvador case study did not show any significant correlation between education or income and (conscious) strategies taken to cope with and adapt to (increasing) disaster risk. However, the analyses indicate a significant correlation between past disaster impacts and the use of coping strategies ( $p < 0.001$ ; adjusted  $p < 0.05$ ). In other words, those households who in the past were affected the most were also most likely to take risk reduction measures into their own hands (76.9% for Hurricane Mitch; 88.2% for Hurricane Stan).

In the Rio case study, the level of education could be tested against people's ability to name any types of risks in the settlement. The result was the identification of a significant correlation ( $p < 0.00013$ , adjusted  $p < 0.0104$ ). This was the most significant result of the Rio case study, meaning that interviewees with lower education were more likely to see their surroundings as risk free, whereas those with higher education were more aware of existing risks. It was also found that interviewees with a higher level of education were able

to point out a greater number of risks in the settlement ( $p < 0.003$ , adjusted  $p < 0.16$ ). In the San Salvador case study, the survey data did not allow a similar comparison.

#### Factors influencing institutional support

In order to assess if education, income, and/or past disaster impacts influence the institutional support households receive to cope with and adapt to disasters, a series of cross-tabulations was carried out. No significant correlations could be found. However, the data show that, in both case-study areas, the families living at high risk have received more institutional help than those at lower risk. Despite the institutional support received, out of these families, 36% in the San Salvador case study and 63.3% in the Rio case study state that their current level of risk is similar or even worse than before. Additional analyses suggest that there might be a correlation between households being able to express being at risk and having received institutional support. Allowing a 40% error rate, in *Rocinha* a significant correlation could be found between reporting to be at risk and having received institutional help ( $p < 0.005$ , adjusted  $p < 0.4$ ).

#### **Qualitative Analysis of Risk Factors—Differential Vulnerability**

This section presents the qualitative analyses of the factors that influence people's differential vulnerability. The results show how disasters affect people living in informal settlements such as *Los Manantiales* and *Rocinha*, and how this is related to their level of formal education. In contrast to the quantitative analyses presented in the previous section, the qualitative analyses do not investigate the relative importance of education (as opposed to other factors such as income), but aim to provide illustrative examples of the kind of influence education can have on people's level of disaster risk. Thus, it provides an understanding of *how* education is linked to the conceptual framework presented in the third section.

#### *Education: direct effect on aspects that reduce risk*

In both the San Salvador and the Rio case studies, it was found that education can have a direct influence on people's level of risk and associated risk reduction. Based on the comparison of data obtained from interviews, observation, and relevant literature, formal education is considered to have a positive effect on people's:

- Awareness and understanding of existing risk;
- Access to (and provision of) information on risk reduction;
- Acceptance and adequate use of institutional support; and
- Way of coping (by improving their own risk-reduction strategies).

The following sections describe these outcomes in more detail.

#### Awareness and understanding of existing risk

The statistical analyses of the Rio case study show a correlation between people's level of education and their ability to perceive existing risks (see previous subsection presenting the quantitative analyses of risk factors). The interviews with key informants and residents confirm this result. A representative of the Civil Defense of Rio de Janeiro states, for instance, that their work in *Rocinha* clearly shows that formal education is "directly linked to people's ability to perceive risks." With risk awareness being a necessary condition to engage in disaster risk reduction (UNISDR 2002), this demonstrates the vital role of education for people's adaptive capacity.

In the San Salvador case study, upon probing, virtually all interviewees at high risk (i.e., 97%) named either flooding or landslides as an imminent risk to their lives, and the majority (i.e., 83% of the focus group) could mention at least one factor that makes them more vulnerable (compared with other residents living at lower risk) (Wamsler 2007). However, and in accordance with the Rio study, the qualitative analysis of the 2006 interviews shows that it was the illiterate interviewees at high risk who could not mention any additional risk factors.

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**Box 1. Access to information on risk reduction.** Ana, single mother, 40 years old, 11 years of education, is currently taking tests to enter university to study journalism. She lives in *Cachopa*. She has not received any institutional support to improve her situation, but she managed to get a stipend from the renowned, private language school *Cultura Inglesa* for her son to study English. When asked about the ways she copes with existing disaster risk, she mentions a range of different strategies including:

- Looking for risk information on the internet
- Investing in the structure of the house
- Improving the electricity (distribution and outlets)
- Not throwing trash on the streets
- Sending her son to study outside the *favela* (slum)

When asked about her interest in moving to another and more secure area, Ana states that there is a difference between *living in* a favela and *being the favela* (thus referring to the associated stigma of its residents), and then highlights that she *only* lives here because she does not have the opportunity to live anywhere else.

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#### Access to (and provision of) information on risk reduction

In both the Rio and the San Salvador case studies, observation and interviews with residents suggest that a higher level of education has a direct effect on people's access to information. This includes information on existing:

- Hazards and other threats;
- Safer places to live;
- Measures to reduce risk;
- Knowledge about potential institutional support; and
- Laws and people's own rights.

As an example, Ana, a highly educated female resident from *Rocinha*, mentions searching for risk information on the web as one of her main coping strategies (see Box 1). Residents from *Rocinha* also suggested that better-educated people have better means of expressing themselves, which is crucial for informing others (including authorities) about their own risk situation. In line with this, key informants state that people with higher levels of education are more likely to be successful in their contacts with authorities and emergency officials. This was also confirmed in the San Salvador case study, where those residents with the lowest levels of education were the ones who frequently mentioned that (a) they do not have any idea of how they could improve their situation and (b) they do not know of any institutions that could assist them.

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**Box 2. Acceptance and use of institutional support.** Francisca lives with her husband and her baby in the high-risk area *Laboriaux*. She is 26 years old and has 8 years of education. When asked how she copes with the imminent risk of landslides, she mentions a range of different strategies, including staying at home in order to not miss any information from the Civil Defense Service.

Maria, a female resident from *Los Manantiales*, with 6 years of education, takes an active part in the community-based work offered by the institution FUNDASAL to reduce existing risk. Although several interviewees expressed their reluctance to actively participate, she says: "It is true that we [meaning the poor] have to work [in order to reduce our risk], but this is how it is, we have to work hard if we really want to make a change here and have a better life."

A technical staff member working in *Rocinha* for the governmental program "Programa de Aceleração do Crescimento" describes the importance of education: "Facing a disaster, the affected families have a lot of issues to solve and to deal with. Those who have a better education can generally cope better with the post-disaster situation than those who have less education, [...] because education helps them to make better decisions, for instance, when they have to decide where to go to an emergency shelter, when they have to deal with authorities or other institutions which offer different types of assistance, etc. These are cases where better education will be of help. Hence, people's education is certainly a determinant [for people's level of risk]."

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### Acceptance and adequate use of institutional support

The qualitative analyses of both case studies suggest that people with higher levels of education are more likely to be responsive to disaster warnings and alerts (cf. Cutter et al. 2003, Lindell and Perry 2004). The Civil Defense of Rio de Janeiro notes that one of the main reasons behind the differential vulnerability of people living in the same community is that warnings and alerts are ignored. A community worker in *Rocinha* supports this, stating that education makes residents less suspicious of the authorities and more likely to accept institutional support, if considered adequate. In the San Salvador case study, no such clear correlation could be found. However, interviews and observation suggest that people's level of education (and not their income) influences people's adequate use of institutional assistance (see Box 2). This refers to people's active participation, maintenance of physical risk-reduction measures, regular contributions to local emergency funds, and adequate use of credits received.

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**Box 3. Improved coping through education—education as a conscious strategy.** Ana, single mother with 11 years of education, lives in *Cachopa*. When asked how she deals with existing risks, she mentions sending her son to study outside the *favela* so that his education is not affected by the problems within the *favela*, including natural hazards, shootings, power cuts, striking teachers, etc. In contrast, Francisca, single mother with 8 years of education, living in *Laboriaux*, was sending her two eldest sons to the local school. However, after the devastating landslides in 2010 and the resultant closure of the local school, she decided to send them to her mother. Francisca mentions this as an active strategy to cope with the recent disaster. She highlights that she does not want her boys to miss any classes and that she is afraid she will not be able to run out of her house with her two boys *and* her baby in case of another landslide.

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### Improvement in own coping strategies

In both study areas, it was only after probing that around 65% of the interviewees mentioned any kind of strategies or improvements made to reduce their risk. However, observation and interviews with key informants show that virtually all residents in *Los Manantiales* and *Rocinha* are actively adapting to their risk situation, which is a common feature in many southern low-income settlements (cf. Wisner et al. 2004, 2007, Jabeen et al. 2009). The strategies the residents are aware of, and thus are consciously applying, are mainly of a structural or economic nature (such as improvements in their houses or taking credits). After probing, it is mainly those interviewees with a higher level of education

who mention and actively use other types of strategies. These include strategies that are directly related to education, such as:

- Temporarily or permanently sending children to study outside own settlement (see Box 3);
- Improving access to schools (e.g., paving streets or building bridges);
- Encouraging dependents to study;
- Taking jobs outside their own settlement;
- Being able to change employers (e.g., depending on changing demands, which can be influenced by climate variability and extremes); and
- Staying informed about existing risk (by using different sources).

Data suggest that it is not necessarily the number of strategies, but the use of different types of strategies that differs among people of different educational levels. This increases the likelihood of tackling not only one, but several different risk components (i.e., existing hazards, vulnerabilities, response mechanisms, and recovery mechanisms). The qualitative analysis further shows that, in contrast to education, increased income often leads to an increased number of, or focus on, physical improvements, which does not necessarily lead to reduced risk (Wamsler 2007). In addition, better-off households are more likely to opt out of community engagement, which can have a negative effect not only on social cohesion but on the disaster resilience of the entire community (Wamsler 2007).

Finally, two education-related issues were identified to be of special relevance for efficient local coping: having a formal job and people's interest in moving to a lower risk area (within or outside the settlement). The following subsections explain their potential to reduce risk and how they are related to people's level of education.

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**Box 4. Importance of having a formal job to cope with disaster risk (and link to education).** “When I was living in the *favelas* in the 1960s, parents commonly warned their children: ‘If you drop out of [elementary] school, you won’t be able to get a job and you’ll end up collecting garbage.’ Several years ago when I was in Rio, 200 vacancies opened up for garbage collectors. Over 4000 people applied, and a high-school diploma was mandatory” (Perlman 2010:231).

According to the Director of *Rocinha*'s Residents' Association, the residents' level of education influences their level of disaster risk in two ways: (1) lower education generally influences a greater number of children per family and, (2) it restricts people's access to the formal working sector. Regarding the latter, he states: “These [less-educated]

residents may not be able to get a [formal] job, as many formal jobs require a certain level of education, degree. And we know that not having a [formal] job, or only having an [informal] job with low wages, makes people incapable of moving out [of the risk zone] and to a better place.”

In *Cecilio del Valle*, Mercedes reports on her uncle who recently died, leaving behind four children. As her uncle had formal employment, she is now getting his life insurance: “This allows us to take care of his house and the children. He left behind four small children, the oldest one will soon be 14.”

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#### Chances of obtaining a formal job

Neither the qualitative analysis of the San Salvador case study nor that of the Rio case study indicate a strong correlation between formal education and income. However, both studies show the importance of having a formal job for coping with disasters. In fact, helping dependents obtain a formal job is part of people's coping strategies (Wamsler 2007). Interviewees state that a formal job allows them easier or cheaper access to:

- Post-disaster credits;
- Life insurance;
- Pension after retirement or in case of inability to work;
- Secure income (e.g., job not vulnerable to climate variables and extremes);
- Health insurance;
- Ability to take sick leave (e.g., in the wake of disasters);
- Other workers' benefits (e.g., regulated hourly rates, security regulations);
- Direct post-disaster assistance from employers; and
- An official address (of the employer) required to register children at school.

The importance of these issues is demonstrated by the case of an informal worker living in *Divina Providencia* who pays into the social security system through deals with entrepreneurs who certify his employment, thus enabling him to get (illegal) access to formal insurance mechanisms. In addition, people working in the informal sector often need to work at several jobs and, thus, have little time left over for community-based efforts to reduce risk (Wamsler 2007). Finally, interviewees suggested that level of formal education is a determinant for people obtaining a job in the formal sector (see Box 4), and that the correlation between formal education and income is less likely for male residents. The latter may relate to the fact that there are more well-paid jobs for men (than for women) that do not require any formal education.

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**Box 5. Education and interest in moving to lower risk areas.**

During an interview in *Los Manantiales*, Esperanza stated that she has always wanted to move somewhere else in order to protect her children. However, her husband has never been willing to move, creating a lot of stress and tension, which finally led to their separation: “I can tell you that in the past, until recently, it was nearly impossible to live here [due to all the disasters occurring], and I was close to moving somewhere else, and I even escaped with my children and got separated from my husband, because he never wanted to leave this place.” Esperanza finally did not move out of *Los Manantiales* because her risk level was considerably reduced with the help of FUNDASAL’s upgrading program.

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Moving out of a risk area

Although the quality of the education available to people in low-income settlements in San Salvador and Rio is often substandard, the study found indications that education may be the key for moving to a more secure area. This includes low-risk areas within the same settlement, and (to a lesser extent) moving to a formal part of the city where risk and risk reduction are less shaped by informal processes. More interviewees with higher education mentioned moving somewhere else as a potential option and had some ideas about how this could be realized.

In a study about Rio’s informal settlements, Perlman (2010) found three factors that increased the likelihood of a person moving from the *favela* (slum) to a *bairro* (formal settlement). The people who moved tended to be the ones who (a) had fathers with relatively more education; (b) had more education themselves; and (c) were more knowledgeable about Brazilian politics. In contrast, no correlations were found between moving out from a *favela* and people’s income level. In the same study, staying in an informal settlement was found to be correlated with other indicators of well-being, such as having a formal job, being a homeowner, and/or being active in a community organization (Perlman 2010). Interestingly, in the San Salvador study, all the interviewees who had an exceptionally high level of education and a formal job (at a governmental agency) had been moving to a lower risk area within their respective settlement (namely, *Los Manantiales* and *Cecilio del Valle*). Finally, both the San Salvador and the Rio case studies demonstrate the importance of women as the driving force behind families moving out, mainly motivated by their strong wish to protect their children (see Box 5).

*Education: mitigating effects on aspects that increase risk*

Both the San Salvador and the Rio case studies found that a higher level of education has an influence on risk because of

its potential to reduce underlying risk factors. These factors were identified to include:

- Poor health;
- Organized crime;
- Teenage pregnancy and single motherhood; and
- Informal settlement growth.

The related analyses and outcomes presented below describe: (a) the appearance or relevance of the issue in the context of the case study areas; (b) its relationship to education; and (c) its influence on disaster risk. Thus, it illustrates how education can have a mitigating effect on underlying risk factors, how this is linked to the conceptual framework presented in the third section and how the different factors are mutually reinforcing.

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**Box 6. Poor health: an education-related underlying risk factor.**

Claudia, a less-educated female resident of *Los Manantiales* suffers from a kidney malfunction. Before falling sick, Claudia was earning money by informally cleaning in different households outside the settlement. During an interview, she described how not having health insurance and the resulting difficult access to adequate health services has caused her health to deteriorate and, thus, increased her level of disaster risk: “No, it would just be fantastic if I would have any [health] insurance. The insurance makes a big difference. Without it, I have to go to the Hospital Rosales and wait there for around 3 days in the emergency room until I can get a bed. In theory, I would have to do this every week, but [because of this situation] I do not go any more [...] and therefore my health has been getting worse.” Claudia’s son just finished his third year at school. Due to his mother’s health and resulting financially difficult situation, he is now forced to leave school in order to earn money for her and his family. His mother is not happy about this, but she is proud that her son is taking responsibility: “You know, this boy is very smart. He would like to continue studying at the University, but now this is not possible. No, because he has to work. ‘Since I am helping you mom’, he tells me.”

Ernesto is an illiterate resident of *Los Manantiales*. He has lived all his life next to the river, but now his situation makes him worry because he lost his leg in a work accident, lost his wheel chair (which had been given to him by a church) during the floods in the aftermath of Hurricane Stan, and is now responsible for taking care of his two grandchildren: “I have always been living on the river banks, but when I could still walk this did not worry or afflict me. But now it does [...] And imagine, my daughter leaves me here with her two children.” Since not only Ernesto’s wheel chair, but also his house and his land were washed away during Stan, he is currently living on his neighbor’s land. His son had to leave school and is unable to work, because he has to take care of his handicapped father.

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### Poor health

*Context:* In *Los Manantiales* and *Rocinha*, people's physical and mental health status is low compared with the surrounding formal settlements. Lacking waste and waste-water facilities, contaminated spring wells, overcrowding, violence, and poorly ventilated houses are part of the causes for the high number of illnesses (e.g., Verly 2009). Informal and physically demanding work is another reason why people in both case-study areas repeatedly report having physical and mental health problems.

*Education*→poor health: People's level of education is an important determinant of health. The number of years of schooling has been identified as the second most relevant variable to the health status of adult Brazilians (after age) (Fonseca et al. 2000). The progression of diseases is exacerbated by frequent abandonment of treatment which is directly related to low levels of education (e.g., Ferreira et al. 2005). Interviews further revealed that many of the less-educated residents of *Los Manantiales* and *Rocinha* are forced to take on informal jobs which are often physically demanding, with unregulated working hours, few safety restrictions, and no health insurance, leading to an accentuated number of injuries, physical wear, and mental stress.

*Poor health*→disaster risk: Although good health is said to be a key resource for disaster survival (e.g., Enarson 2000, Wisner et al. 2004), health deficiencies make people more vulnerable. As illustrated in Box 6, poor health reduces people's opportunities for earning a living and might force other family members to leave school early to support their family. Interviews suggested that some health conditions, for example being disabled or HIV-positive, are likely to increase vulnerability by adding to the existing stigma of living in a low-income area. Furthermore, health is a determinant of people's capacity to respond to disasters. A timely evacuation on the steep stairways and in winding alleyways may be very difficult for a person with a reduced physical capacity (see Box 6). People's health is also likely to affect their capacity to recover. For example, an already weakened immune system decreases the chances of withstanding the infectious diseases that are often spread in the aftermath of disasters (cf. Wisner et al. 2004). Another example is illustrated by a woman living in the high-risk area *Laboriaux*, who did not suffer any direct disaster impact after the 2010 landslides. However, due to already having a history of psychological illness, the landslide affected her strongly, and she had great difficulty returning to the way she had lived before.

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**Box 7. Organized crime and corruption: an education-related underlying risk factor.** Several interviewees report how rivalries between different groups (of different political parties or different violent gangs), in combination with corruption, negatively influence adequate assistance. Luis, living in *Cecilio del Valle*, states: "The retention walls were probably built in the least-affected areas, and

people in the areas most at risk were left with nothing. The local board helped in the sense that they were trying to access help from different organizations. But then, well, this is what one can often see here: After the earthquake, most people, including the local board, knew which families were most in need; however, in practice, things turned out differently. They barely took them into account, those that were most in need." Another resident states that not only the assistance from the local board, but also the assistance from the municipality is politically influenced: "Well, this is how the political parties work [...]: it is only some few people who really get some help [...], they give corrugated iron sheets, scantlings, cement or bricks [...], but they only give to some."

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### Organized crime (and corruption)

*Context:* Abandoned by regular law enforcement, the residents of *Los Manantiales* and, to a greater extent in *Rocinha*, must rely on the gangs to keep order, allowing the residents to go about their daily lives. In the San Salvador case study, flooding and landslides were generally seen as the main risk to lives and livelihoods. Earthquakes and windstorms ranked next in importance, together with the lack of job opportunities and the insecurity due to *maras* (gangs). There are daily reports of residents of *Los Manantiales* being killed, harassed, violated, and robbed (FUNDASAL 2010). In the Rio case study, the most frequently mentioned risk after landslides was to be caught in the crossfire during one of the police's sporadic raids in their effort to control violent gangs.

*Education*→organized crime: Primary and secondary education is said to be one of the most important measures to sustainably reduce enrolment in the drug industry (Dowdney 2003). In San Salvador, community leaders explicitly mention the direct relationship between low levels of education and violent behavior shown in the form of organized crime and intra-family violence. In addition, in both case studies, it was found that children who drop out of school are more easily recruited by criminal gangs (Dowdney 2003, FUNDASAL 2010), and young men with little education might see no other way to make a sustainable living than to work for the trafficking movement (Dowdney 2003). The difficult access to the employment market for youngsters coming from informal settlements is another contributing factor to the steady inflow of new recruits to criminal gangs (Perlman 2010, FUNDASAL 2010).

*Organized crime*→disaster risk: Because of the violent conflicts between different gangs and the police, male life expectancy is low, and many residents fear the police and see them as corrupt and brutal. This creates widespread mistrust, not only of police officers, but of any kind of authority, including emergency and development planning officials. In the San Salvador case study, national and municipal governments were often seen as unhelpful and even a hindrance to people's risk-reduction efforts (Wamsler 2007). In addition, organized crime, corruption, and political

factionalism have an eroding effect on trust and social capital *within* the informal settlements, affecting local community cohesion and community-based coping mechanisms (Wamsler 2007). They also dilute the information flow about jobs and other opportunities, which is spread through informal community networks (Perlman 2010), including information on potential risk reduction and available institutional support. In Rio, many residents' associations are said to have been threatened or taken over by drug gangs and, thus, participation in community organizations has drastically decreased (Perlman 2010). Observations and interviews show that, in both case-study areas, the affected people are, however, highly dependent on mutual help. Loss of social capital due to organized crime can thus be assumed to have serious effects on people's level of risk. In addition, organized drug trafficking can be seen as a direct factor to availability and abuse of illegal substances, which can lead to increased risk (Uchtenhagen 2004, National Institute on Drug Abuse (NIDA) 2010). Interviewees described the trafficking movement and the associated drug abuse and violence as a threat to health and well-being through increased mortality and psychological stress for the residents (cf. Uchtenhagen 2004, Box 7).

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**Box 8. Teenage pregnancy: education-related underlying risk factor.** A woman living in *Cecilio del Valle* states: "You just have the money to pay bills but not to eat. I bought a pair of shoes for my son so that he can go to school, and then I could not pay the electricity bill. The next [electricity] bill will be double to be paid next month."

A community leader from *Rocinha's* Residents' Association links teenage pregnancy to disaster risk and education: "People with little education often end up having very large families, particularly in this part where the risk is highest, which is the area of *Macega*. It is perhaps due to people's lack of formal education that the people there haven't had many opportunities to study and gain knowledge about things [...]. The number of children tie the mother to their home, and also the father. Many mothers have to quit their studies because they become pregnant at a very early age, too young; and the responsibility of caring for a child, or for two children, becomes too much burden, so that they cannot continue going to school."

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#### Teenage pregnancy (and single motherhood)

*Context:* Interviews and observations indicate a high frequency of teenage and pre-teenage pregnancies in the studied areas. When discussing risks "off the record," early pregnancies are almost as frequently mentioned as risks related to drug trafficking.

*Education*→teenage pregnancy: Teenage pregnancy is known to be more common among girls with low levels of education (Busso 2002, Stern 2002, Observatório da Educação 2006), and there is some indication that the risk of becoming pregnant

is higher for teenage girls who are not attending school (Observatório da Educação 2006).

*Teenage pregnancy*→disaster risk: Single and teenage mothers in *Los Manantiales* and *Rocinha* face a variety of challenges that may contribute to their vulnerability to disasters, such as increased expenses, difficulty continuing with studies or income-earning activities, potential health complications during and after pregnancy, and possible rejection from their family or partner. Interviews and observations also show that early and unplanned pregnancies often lead to vulnerable family constellations, such as single-head households, and add to the responsibilities of the parents of the young (or single) mother. According to disaster literature, mothers (and even more single mothers) are especially at risk in disaster situations (Enarson 2000, Cutter et al. 2003). Being responsible for a small child (or several) is likely to affect a woman's ability to cope with and respond to disasters (see Box 8).

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**Box 9. Informal settlement growth and stigmatization: an education-related underlying risk factor.** Eugenio from *Rocinha* says that the *favela's* reputation as a violent and lawless area creates mistrust in its residents, even though the majority of them are the victims rather than the perpetrators. The stigmatization made it difficult for him to find formal work, and during shoot-outs between traffickers and the police, he cannot make it to his job without risking his life, adding further weight to his employers' discrimination.

In the study area in San Salvador, interviewees from *Cecilio del Valle* describe how governmental staff is completely ignorant about their situation and do not even want to set foot in their settlement: "The government has never had the kindness to visit these remote [meaning informal] places, [...]. Consequently, governmental assistance is scarce: "No, they have not given us anything. We only see them passing by. As we are 'private' [meaning informal], as they say it. [...] They do not care about us, only for the ones that have formally accessed their land."

How people are stigmatized due to their address (i.e., the name of the settlement they live in), is illustrated by Alejandro, resident of *Los Manantiales*: "Before, this community wasn't called New Hope; it was called River Banks. This was its name. [...] Absolutely nobody wanted to provide any assistance for River Banks, no single organization wanted to help us saying that River Banks means that it is located next to the river, and this is true. But we came here because it was actually the Municipality who offered here land for housing, and if we would build construction walls, we were told that we would get legal tenure." However, it was only after many years of fearing eviction, and only after the FUNDASAL upgrading project providing assistance for legalization and physical improvements for risk reduction that they were given legal tenure.

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### Informal settlement growth

*Context:* Alongside all the difficulties in *Los Manantiales* and *Rocinha*, there exists great ingenuity: Materials and objects are constantly sold and recycled to fill new functions for housing, microenterprises, or risk reduction. Old car tires are converted into retaining walls or embankments, plastic sheets and corrugated iron into water gutters. Problems such as insufficient living space are solved by constructing another floor or filling up river banks, missing electricity outlets by simply drawing another cable, and many residents work informally in different fields. However, there is a downside to the fast-paced informal development. Overcrowding, unsafe construction, the absence of waste and water management, permanent fear of being evicted, deforestation, and excavated slopes are part of daily life.

*Education*→informal settlement growth: Formal education may be a determinant for the prospects of moving to a formal part of the city, where risk and risk reduction are less shaped by informal processes (cf. subsection on “Moving out of a risk area”). In addition, the poor quality of public education in El Salvador and Brazil particularly affects children in informal settlements (see following subsection on “Disaster impact on people’s education”), leading to a continued separation and an amplification of the differences and inequalities among people living under “formal” and “informal” conditions.

*Informal settlement growth*→disaster risk: The impact of informal settlement growth on people’s level of disaster risk is related to a range of different aspects, including residents’ stigmatization, exclusion from formal decision-making processes, insecure tenure, and inadequate housing and infrastructure. The interviews in both study areas show how living in an informal settlement constrains people’s life opportunities, such as obtaining a job or accessing institutional assistance (see Box 9). Living under informal conditions, without having an officially recognized address (cf. Censo Domiciliar 2010), also restricts people’s access to education (where an address is required to register children at school) and their ability to take part in decision-making processes (cf. Perlman 2010, UN-HABITAT 2010). Informality can further be equated to residents’ constant fear of being evicted, which can negatively affect people’s motivation to improve their risk situation (Wamsler 2007). In addition, informal building processes result in housing conditions and infrastructure that cannot resist hazard impacts, create additional hazards, and obstruct disaster response and recovery (see Box 10). As for recovery, the access to structures and mechanisms for recovery is problematic for people who do not have tenure and informal workers who lack associated rights (cf subsection on “Chances of obtaining a formal job”).

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**Box 10. Informal settlement growth and insecure tenure: an education-related underlying risk factor.** The examples of Maria, living in *Laboriaux* (Rio), and Eugenia living in *Cecilio del Valle* (San Salvador), demonstrate the importance of having legal tenure for residents’ level of risk. Eugenia does not own the land she is living on and says: “But imagine, not only does one not have a secure entrance to one’s own house, if in addition I would spend a lot of money on [improving] this, and perhaps the next day they come and say ‘leave, go away from here’ [...]” Maria, 44 years old with 10 years of education, lives with her husband and children. Her children got a scholarship from the church to study. When asked about the ways she is coping with existing risks, she mentions being a homeowner (as opposed to renting) as a strategy, as well as investing to improve her house and plot to become less vulnerable to disaster impacts. As she earns her living informally through a local catering business, she does not want to move elsewhere. In fact, she calls *Rocinha* the perfect place to live and run a catering business, because its central location makes it easy to attend to clients in the wealthier areas *São Conrado* and *Ipanema*. She says that her living place offers her the opportunity to have a big kitchen, natural springs with fresh water, and a marvelous view. The only problem for her is that local disasters can negatively affect her business. After the disaster-related deaths in 2010 in *Laboriaux*, people were not in a *clima de festa* (party mood). Some people were moving away from *Laboriaux* and the local demand for her birthday cakes and party catering was low.

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### *Disaster: impact on people’s education*

Both the San Salvador and the Rio case studies show that disasters strongly affect residents’ lives and livelihoods, including short-lived and long-lasting impacts on their level and quality of education. In the aftermath of disasters, children are often obliged to temporarily, or even permanently, leave school. Reasons are:

- Children have to work to economically support their family;
- Children have to take care of injured family members (see Box 6);
- No money for paying school fees (due to increased post-disaster expenses or burglaries in damaged and thus easily accessible houses);
- Loss of belongings required to attend (or change) school, including school uniforms, books, ID documents, etc.;
- Destruction of local school; and
- Permanent closure of local school due to being in a high-risk zone.

In other cases, children do not have to leave school. However, temporarily or permanently they have to travel to another school far away from home. This results in:

- Additional expenses for bus fares;
- Reduced time available for homework, other responsibilities, and sleep; and
- Children going to school only every other day (as the early mornings become too stressful over time).

Interviewees report on families that, after disasters, had to move to other areas where their children could not attend the local school. This can be due to the fact that:

- The new school cannot take more pupils; or
- The parents do not (yet) have a recognized address to register their children at the new school.

Many of the female residents highlight that there are many factors in the aftermath of a disaster that make it difficult for children to concentrate on their studies. Such factors are:

- Reduced or lack of space for studying (with houses being partly damaged or destroyed);
- Electricity failures or outages, making it impossible to study in early morning or after sunset;
- Difficult and dangerous way to school;
- Community distress;
- Psychological distress of families;
- Pupils having increased responsibilities, having to take care of sick family members, the reconstruction of houses, part-time jobs, etc.;
- Living in temporary shelter or in houses with little security or no privacy (i.e., lacking doors, walls, etc.);
- Family disruptions due to a permanent move of (some of the) children to other family members in more secure areas; and
- Increased health problems that affect young school children disproportionately.

Assuming that education is crucial for people's adaptive capacity (which is confirmed by this study), disasters and associated impacts on people's education are likely to result in a vicious circle of increasing risk and deteriorating education. However, it is important to highlight that the education in low-income settlements is inadequate, even without disaster occurrence. Classes are often cancelled due to power cuts, shootings, and absent or striking teachers. Not every teacher wants to work in a slum. Not only because they consider it to be unsafe, but also because of the social devaluation that these places exhibit (Gonçalves 2010, Perlman 2010). Nevertheless, although the quality of the education in both case-study areas is obviously low (and has

even declined in some parts), several interviewees mention the better access to education for their children as one of the reasons why they feel less at risk today.

## **DISCUSSION: TOWARD SUSTAINABLE ADAPTATION**

This section discusses the influence of formal education in determining societies' adaptive capacity. First, a summary of the different key results is presented, followed by a comparative analysis of the quantitative and qualitative results of the San Salvador and Rio case studies. Finally, the outcomes are discussed in the light of the conceptual framework presented above.

### **The Role of Education for People's Adaptive Capacities: Summary of Key Results**

At the beginning of the two case studies, virtually all information gathered seemed to indicate that education does not play a major role for people's level of disaster risk. Without exception, the international risk management experts interviewed suggested that education plays a minor role, with the only risk-reducing influence being its positive influence on people's level of income. In addition, none of the consulted international *and* national experts was aware of any specific research analyzing the interlinkages between people's level of education and disaster risk, nor of any specific databases that would allow such analyses. Nevertheless, a more in-depth study comparing the quantitative and qualitative data gathered showed a different picture. In fact, the qualitative results of both the San Salvador and Rio case studies indicate that formal education has a positive and direct effect on:

- People's awareness and understanding of existing risk;
- Their access to, and provision of, information on risk reduction;
- Acceptance and adequate use of institutional support; and
- The improvement of people's own coping strategies.

Regarding the latter, two issues related to formal education were identified to be of special relevance for efficient local coping: having a formal job, and people's interest (and efforts) in moving to a lower-risk area within or outside their own settlement. In addition, the qualitative results suggest that a higher level of education can influence disaster risk due to its potential to mitigate underlying risk factors. These factors were identified to include:

- Poor health;
- Organized crime;
- Teenage pregnancy and single motherhood; and
- Informal settlement growth.

The quantitative analyses conducted support some of the qualitative results, for instance, by indicating a significant correlation between:

- Interviewees' education and ability to point out any risks in their settlement (Rio);
- Interviewees' education and the number of risks they were able to point out (Rio); and
- People's (lower/higher) average levels of education and living in a (high/low) risk area (San Salvador and Rio).

Other important results from the surveys in 2009–2011 are the identified correlations between:

- Households affected by Hurricane Mitch in 1998 and households affected by Hurricane Stan in 2005 (San Salvador);
- Impact from past disasters and local coping strategies (San Salvador); and
- Education and income of women (Rio).

Finally, in the San Salvador case study, the quantitative analysis of the institutional database from FUNDASAL from 2003 indicates correlations between:

- Education of head of households and total household income;
- Education (of working adult) household members and total household income; and
- Education of head of households and disaster risk.

### **Comparative Analysis: the Climate and Education Nexus**

The summary of the key results presented above shows that education has both direct and indirect influences on people's level of disaster risk. This section highlights some of the results by discussing the differences between the two case studies.

#### *Education and disaster risk*

In the Rio case study, through statistical analysis, a clear correlation was found between the educational level of the interviewee and his or her ability to point out any risks in the settlement. This result was independently confirmed in interviews with key informants. Accordingly, less-educated people seem to be more likely to downplay their own risk. If this were the case, the outcome of the 2003 database from San Salvador, which identifies a negative correlation between education and disaster risk, becomes more significant (than it first appeared). The definition of high and low risk in this database is based on people's own risk perceptions (as opposed to more objective risk evaluations). In addition, the database shows the situation in the settlement before the FUNDASAL upgrading program and associated risk awareness campaigns were carried out. The identified correlation could thus actually

be stronger than what the numbers show. Interestingly, further analyses of the same database not only show a correlation between education and disaster risk, but also indicate a significant correlation between education and income, but *not* between income and risk. This gives rise to the high importance of education as opposed to income. Pointing toward the same issue, the Rio case study showed no significant correlation between education and income, either for households or for men—only for women (see below).

Comparing the qualitative and quantitative results of the San Salvador case study, it is possible to argue that there is an important link between people's level of education and their efforts to reduce risk through different coping strategies. That this correlation did not prove to be significant in the quantitative analysis is probably due to the fact that this analysis was only based on the coping strategies that the interviewees mentioned (and thus are aware of). People's conscious coping strategies are, however, mainly related to structural or economic improvement (Wamsler 2007), leaving out residents' numerous other strategies, which were identified in the qualitative analysis.

#### *Institutional support for risk reduction and adaptation*

From the case studies, it can be concluded that the current institutional assistance provided to reduce and adapt to current risk is insufficient. In fact, although in San Salvador those households at high risk have received more assistance (compared with those at moderate risk), they were hit quite strongly and in a similar way by both Hurricane Mitch in 1998 and, 7 years later, by Hurricane Stan in 2005. In the Rio case study, similar analyses could not be made. However, whereas in the Rio case study area the households at risk have received more institutional help, 63.3% of them state that their current level of risk is similar or even worse than before. In addition, virtually all interviewees agreed that the current measures are not sufficient in a context of increased numbers and frequency of disasters, casting current institutional approaches into doubt.

#### *Results with a "gender twist"*

One of the results of this study is that formal education seems to be of special importance for determining women's level of risk. This was confirmed by statistical analyses of the Rio case study and the qualitative results of both case studies. The statistical analyses show that, for women, more education is likely to lead to a higher income. No such correlation was found for the male participants. The qualitative analyses suggest that this may be due to the fact that there are many male-dominated jobs that are relatively well paid, but do not require formal education, whereas this is not the case for female-dominated jobs. In addition, it seems that it is easier for men (as opposed to women) to get a formal job without a certain level of formal education. Knowing the importance of

**Table 3.** Influence of education on existing area-specific risk

Factors influencing people's level of risk	Influence of (lower) education <i>Illustrative examples of how lower levels of education might increase risk</i>
Hazard(s)	<p>Increased exposure to existing hazards due to high and increasing numbers of people in the same disaster-prone settlement with no option or little interest in moving to lower risk areas, resulting in:</p> <ul style="list-style-type: none"> <li>• Increased proximity of housing and infrastructure to hazards</li> <li>• Expansion of informal settlements into high-risk areas</li> </ul> <p>Intensified hazards and creation of new ones, such as: Floods related to extensive littering and inadequate infrastructure</p> <ul style="list-style-type: none"> <li>• Landslides due to excavation, deforestation, intensive littering, and inadequate construction</li> <li>• Fire due to inadequate electricity connection</li> </ul>
Vulnerability	<ul style="list-style-type: none"> <li>• Concentration of highly defenseless population groups weakened by diseases, conflict, work-related injuries, family disruptions, etc.</li> <li>• Organized crime and corruption affecting community cohesion and information flow on risk and risk reduction</li> <li>• High numbers of teenage pregnancies and vulnerable households with single mothers, numerous children, or other dependents, etc.</li> <li>• High numbers of people working in informal and physically demanding jobs with no or little social protection</li> <li>• Limited access to formal assistance and low influence on decision-making processes (for risk management)</li> <li>• Inadequate housing construction and infrastructure</li> <li>• Mistrust in authorities, including planning authorities and emergency organizations</li> </ul>
Response mechanisms and structures	<ul style="list-style-type: none"> <li>• Reduced mobility of people with poor health, single mothers, and families with many children</li> <li>• Reduced mobility due to low income (e.g., no personal vehicle and lack of money for paying public transportation)</li> <li>• Reduced mobility due to organized crime (resulting in high levels of insecurity and increased expenses for "protection" offered by criminal groups)</li> <li>• Lack of emergency access and evacuation roads (due to informal living conditions)</li> <li>• Limited access to formal response mechanisms (due to informal living conditions)</li> <li>• Mistrust in authorities and thus ignorance of disaster warnings, alerts, evacuations, offered emergency shelter, etc.</li> <li>• Difficulties in communication and contact with emergency organizations</li> </ul>
Recovery mechanism and structures	<ul style="list-style-type: none"> <li>• Difficulty recovering quickly due to poor health conditions</li> <li>• No access to formal recovery credits (due to informal work, no legal tenure, no permission to use assisted housing as collateral, no official address, etc.)</li> <li>• Mistrust in authorities (which might lead to refusal or inadequate use of recovery assistance offered)</li> </ul>

formal employment for people's adaptive capacity (as demonstrated in the "Results" section), formal education is especially crucial for determining women's level of risk.

The importance of formal education in determining women's level of risk also becomes obvious when analyzing the other qualitative outcomes. In fact, the results show an obvious "gender twist" in that the correlations identified between education and the factors that (directly or indirectly) influence risk are more (or only) relevant for women. Obvious examples include teenage pregnancy and single motherhood. Health is another factor where the relevance of women's level of education is especially determinant. The correlation between education and HIV/AIDS in Brazil is one of many examples that illustrate this (cf. Fonseca et al. 2000). With regard to organized crime and substance abuse, again there is a "gender twist." Although it is mainly the men who are directly involved, it is the women who have most of the risk-reducing consequences.

Finally, it is important to highlight the women's role in (actively) reducing risk. Based on the interviews, women are often motivated by their strong desire to protect their children or to provide them with better life opportunities, including improved education.

### From Current Risk Reduction to Sustainable Adaptation

Based on the results presented in the previous sections, the strong influence of formal education on risk and risk reduction can be shown by linking them to the extended risk definition (presented above in "Adaptation and Education: a Conceptual Framework"). Associated conceptual and practical implications are presented in the following.

#### *Conceptual implications of results*

For this study, the conceptual framework used (and presented in the third section of this paper) has proved to be an adequate analytical tool for analyzing the influence of formal education. As opposed to the conventional view of risk, it allows a comprehensive analysis of the interactions among education, disaster risk, risk reduction, and adaptive capacity. People's level of risk is determined here by four different risk factors: the existing and area-specific hazard(s), vulnerabilities, response mechanisms, and recovery mechanisms. The associated measures or adaptive capacities (which aim at reducing each of the four risk factors) can be named: prevention, mitigation, preparedness for response, and preparedness for recovery. On this basis, the results of this study show that education has an influence on *all* the different risk factors and corresponding adaptive capacities. See Tables 3 and 4 for some illustrative examples.

**Table 4.** Influence of education on people’s adaptive capacity.

Factors influencing people’s level of risk	Influence of (high level of) education <i>Illustrative examples of how higher levels of education might reduce risk</i>
Precondition for adequate selection of adaptation measures	<ul style="list-style-type: none"> <li>• Increased risk awareness</li> <li>• Better access to information on risk, risk reduction, offered institutional assistance, etc.</li> <li>• Greater ability to assess, and provide authorities information on, own risk situation</li> <li>• Increased acceptance of (adequate) institutional assistance</li> </ul>
Prevention	<ul style="list-style-type: none"> <li>• A certain level of community cohesion, good health, time availability, and financial resources</li> <li>• Moving out of a risk area (within own settlement or outside own settlement)</li> </ul>
Mitigation	<ul style="list-style-type: none"> <li>• Use of an increased number of risk reduction measures, including non-structural measures</li> <li>• More active use of education-related coping strategies, such as sending children to study outside their own settlement</li> <li>• Better use of institutional assistance (e.g., through the adequate use and maintenance of constructive measures)</li> <li>• Better selection of adequate risk reduction measures</li> </ul>
Preparedness for response	<ul style="list-style-type: none"> <li>• Acceptance and adequate use of institutional support such as warnings, evacuation, emergency shelter</li> <li>• Active use of education-related coping strategies, such as temporarily sending children to study outside their own settlement</li> <li>• Increased mobility</li> </ul>
Preparedness for recovery	<ul style="list-style-type: none"> <li>• Improved access to post-disaster credits, life insurance, paid sick leave, pension, etc. (due to formal jobs)</li> <li>• Better use of institutional support such as recovery credits</li> </ul>

## CONCLUSIONS

With a worldwide increase in the number and intensity of disasters and global temperature on the rise, the effects of climate change are already being felt. Among those most at risk are the poor in developing countries, often living in informal settlements or so-called “slums.” In order to reduce associated risks, there is an urgent need to better understand the factors that determine people’s capacity to cope with and adapt to adverse climate conditions.

This paper examines the influence of formal education as opposed to income in determining the adaptive capacity of the residents of two low-income settlements: *Los Manantiales* in San Salvador (El Salvador) and *Rocinha* in Rio de Janeiro (Brazil), where climate-related disasters are recurrent. The research explores the potential of promoting formal education as a way to increase people’s adaptive capacity. Data were collected through interviews, surveys, literature review, and observation, and both statistical and qualitative data analyses were applied. The statistical analyses investigate how formal education influences people’s level of risk, their coping strategies, and the institutional support received. The qualitative analyses explore (direct and secondary) effects that education may have on disaster risk, and vice versa.

The results indicate that formal education may have a more significant role in determining people’s level of risk and their adaptive capacity than has been hitherto acknowledged. In fact, in both case-study areas, the average level of education was found to be lower for households living at high risk (as opposed to residents of lower risk areas). This positive influence of people’s level of education was identified to be twofold due to (a) its direct effect on aspects that reduce risk and (b) its mitigating effect on aspects that increase risk. On the one hand, formal education was seen to have a positive

effect on issues such as people’s level of awareness and understanding of existing risks; their access to information on (the adequate use of) potential risk-reduction measures; chances of obtaining a formal job; and their interest in moving out of a risk area. On the other hand, formal education has the potential to reduce underlying risk factors such as poor health, organized crime, teenage pregnancy, single motherhood, and informal settlement growth (including the stigmatization of slum dwellers, exclusion from formal decision-making processes, insecure tenure, and inadequate housing and infrastructure). The results suggest that education plays a more determinant role for women than for men in relation to their capacity to adapt. In light of these results, the identified limited effectiveness of institutional support for risk reduction might also relate to the fact that the role of formal education has not been explored sufficiently thus far.

Although further research is needed to test the validity of the findings in different contexts, it can be concluded that promoting (improved access to and quality of) formal education as a way to increase people’s adaptive capacity is justified, not only because of its potential influence on increasing people’s level of income. This is also supported with respect to the negative effects of disasters on people’s level of education, which in turn reduce their adaptive capacity, resulting in a vicious circle of increasing risk. The strength of this adaptation approach lies in the fact that formal education was shown to influence *all* the different risk components and associated capacities without predetermining concrete or inflexible risk-reduction measures. In this context, formal education was especially crucial for people’s capacity to recover, allowing them to bounce back from disaster impacts by quickly establishing new means of livelihood or re-establishing previous ones. Finally, the conceptual

framework used in this study proved to be an adequate analytical and practical tool that could help strengthen current planning strategies for investments in climate-change adaptation.

Responses to this article can be read online at:  
<http://www.ecologyandsociety.org/vol17/iss2/art2/responses/>

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<sup>[1]</sup> The definitions are as follows: Prevention (or hazard reduction) aims (to increase the capacity) to avoid or reduce the potential intensity and frequency of existing or likely future hazards that threaten households, communities, and/or institutions. Mitigation aims (to increase the capacity) to minimize the existing or likely future vulnerability of households, communities, and/or institutions to potential hazards/disasters. Preparedness for response aims (to increase the capacity) to establish effective response mechanisms and structures for households, communities, and/or institutions so that they can react effectively during and in the immediate aftermath of potential future hazards/disasters. Preparedness for recovery aims (to increase the capacity) to ensure appropriate recovery mechanisms and structures for households, communities, and/or institutions that are accessible after a potential hazard/disaster (including risk transfer and sharing).