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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, average levels of education were found to be lower for high-risk households than residents at less risk. In this context, the influence of education was identified to be twofold and due to: (a) direct effects on risk reduction; and (b) mitigating effects on factors that increase risk. The results suggest that education plays a more determinant role for women than men in relation to their capacity to adapt. Moreover, these results suggest that the limited effectiveness of institutional support may be related to the fact that the role of formal education has so far not been sufficiently explored. Promoting improved access to (better-quality) formal education is thus a way to increase adaptive capacity. This is further supported by the fact that disasters were found to have negative effects on education levels, which in turn reduces adaptive capacity, resulting in a vicious circle of increased risk.

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

INTRODUCTION

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 climate-change studies predict a continued rise in the frequency of such events, which include amongst others windstorms, heat waves, heavy rain, floods, and landslides (Intergovernmental Panel on Climate Change [IPCC] 2007). Each year, disasters trigger devastating losses in human lives and economic assets, and developing countries are 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). It is predicted that in Latin America and the Caribbean, 89% of the population will live in cities by 2050 (United Nations 2009). The urban poor, who often live 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).

Despite considerable research into the geological and biological impacts of climate change, little is known about their impacts on the well-being of the world's population and our ability to adapt to them. In fact, knowledge about the adaptive capacities of future societies is one of the most important missing links in predicting the effects of climate change (Lutz 2008).

Against this background, this paper's objective is to help fill the gap by providing new knowledge on the factors that shape people's capacity to adapt to changing climate conditions. Specifically, it aims to examine how the risk and adaptive capacities 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 analyses the complex reality of residents living in disaster-prone informal settlements (so-called "slums"), and illustrates the links between their precarious living conditions, social marginalization and their level of formal education. The focus on formal education is based on recent studies which

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- The wording of the article was revised to improve the comprehensibility of the concepts, methodology, results and their relevance.
- The article was edited in order to strengthen the presentation of the arguments.
- The results were related to a relevant UNICEF study to support the findings and put them into a broader perspective.
- Minor additions were included to avoid any misunderstanding by the reader (e.g. Table 1).
- Additional interview results were included (e.g. Box 1).
- Further explanations were given to support key arguments (e.g. possible biases in the statistical correlation between education and disaster risk, mentioned in the discussion section).

argue that educational attainment may improve 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 even the most important driver. Rather it is driven by the need for a better understanding of the influence of formal education on risk levels. Formal education refers here to studies at primary, secondary, and university level.

The next section describes the research methodology. The third section presents the conceptual framework for the study. Here, the interrelationships between concepts of disaster, risk, and adaptive capacity are identified and discussed from a holistic systems perspective of risk reduction and climate-change adaptation. Links with formal education are also highlighted. The fourth section presents the results, including the similarities, differences, and gaps between the quantitative and qualitative analyses of the two case-study areas (in El Salvador and Brazil). The conclusions are presented in the final section.

METHODOLOGY

This paper is a comparative analysis of two case studies that examine the influence of formal education on the adaptive capacity of residents of informal low-income settlements where climate-related disasters are recurrent. Both case studies form part of the "Forecasting Societies' Adaptive Capacities to Climate Change" project. The project is funded by the European Research Council and coordinated by the International Institute for Applied Systems Analysis (IIASA) (Lutz 2008).

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

In both case studies (hereafter referred to as the San Salvador and the Rio case studies), data was collected through semi-structured and focused interviews, surveys, a literature review, and observation. Both quantitative and qualitative data analysis techniques were applied. Statistical analyses investigated the influence of formal education on local risk levels, coping strategies, and institutional support. The qualitative analyses explored the direct and secondary effects that education may have on disaster occurrence, and vice versa.

Semi-structured interviews were conducted from 2009–2011 and included 118 households in San Salvador and 94 households in Rio. Those households most at risk (the focus group) and those at lower risk (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, this data was collected in 2005 after a season of disasters characterized by a tragic combination of Hurricane Stan, floods, landslides, small-scale earthquakes and the eruption of the Ilamatepec volcano. In Rio, local census data was updated after the 2010 landslides in *Rocinha*. Interviewees were in the main selected randomly (with the help of maps and numeration of households), although in the dangerous case study environments, this sampling procedure was sometimes difficult to follow rigorously.

In addition to the household interviews, around 90 focused interviews were conducted with various other stakeholders. These included 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 the direct and secondary effects that education may have on disaster occurrence (and vice versa), and for crosschecking information from other sources. Consequently, the authors of this study lived for several months in the respective study areas. In the context of the San Salvador case study, institutional databases were also accessed and analysed, and data was drawn from previous research conducted during 2006. The literature review included more than 200 publications. Finally, the preliminary outcomes of both case studies were further assessed and compared during desk work in 2011.

In accordance with the research objectives, the attributes that were analysed (in both qualitative and quantitative terms) were:

- Level of formal education;
- Level of income;
- Level of risk;
- Impact of past disasters (i.e., residents' previous disaster experience);
- Local strategies used to cope with risk or disasters (i.e., residents' so-called coping strategies);
- Institutional support (received to reduce and adapt to disaster risk); and
- Other key factors or attributes.

The analyses were based on data obtained from both interviews and existing databases. For example, household members living in the case study areas were asked: if they consider themselves to be at risk; if they believe themselves to be at higher or lower risk than other community members; how their risk situation has changed; if they have experienced specific disasters; how they cope with the risk and dangers associated with living in the community; if they can name risk reduction measures that they (or others)

undertake; if they receive external assistance; and how past disasters have affected their everyday life (such as the impact on income and education).

Qualitative data analyses consisted of a combination of literal reading, grounded theory (Glaser and Strauss 1967), systems analysis (Sterman 2000) and cultural theory (Thompson et al. 1990). For the quantitative analyses, mainly cross-tabulations were used to identify potential relationships between various attributes and their significance was tested using χ^2 (Chi square) tests. In addition, a linear regression analysis was carried out to identify relationships between levels of education and income, and two log-linear analyses were conducted to examine interactions between three independent variables: previous experience of disasters, income, and risk reduction measures taken). Finally, *t*-tests assessed whether the average level of education of the focus and control groups were significantly different.

Respectively, in the San Salvador and the Rio case studies, a total of 31 and 80 quantitative tests were carried out. First, individual results that were statistically significant at a 5% confidence level were identified. Next, a Bonferroni-type adjustment was performed to adjust confidence levels, as error probability increases with the number of tests conducted. In the following text, probabilities (before and after the Bonferroni-type adjustment) are indicated after the result where applicable (e.g. $p < 0.003$; adjusted $p < 0.16$). In some cases, lower probability results are shown; this is to highlight findings that were considered to be crucial to follow up in future studies.

Various types of triangulations were used in order to obtain a good approximation of "reality" and thus reliability and to compensate for factors that might invalidate conclusions, such as bias in the selection of cases or focus areas and interviewee self-reporting. These included data, methodological, theoretical and investigator triangulation (Harvey and MacDonald 1993, Flick 2006). Other limitations of the analyses are due to statistical methods, contextual differences and approaches, a lack of historical data, and generally difficult access to information 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 vulnerability conditions (*V*). In other words, hazards such as floods, landslides and windstorms are not the sole cause of disasters. It is only when they are combined with vulnerability conditions (such as people or systems susceptible to damage from hazardous events) that disasters occur. In this context a disaster can be defined as, "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).

Disaster risk is conventionally expressed by the following pseudo-equation:

$$R = H \cdot V \tag{1}$$

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. Consequently, it does not link the components of risk to appropriate risk reduction measures. Moreover, recovery actions are rarely 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 begin at the moment a hazard occurs; (b) risk areas affected by a hazard are often still recovering from earlier hazards; (c) the term "hazard" includes primary and secondary hazards (e.g. landslides or cholera following earthquakes and floods) and includes both rapid- and slow-onset events that can develop over time or are successive (e.g. aftershocks) (Wamsler, unpublished manuscript).

These limitations led to the development of an extended definition of risk and risk reduction (Wamsler 2009), which directly links risk components to corresponding risk reduction measures. These include prevention measures (that reduce or avoid hazards), mitigation measures (that reduce vulnerability), response preparedness measures (that improve post-disaster response), and importantly also recovery preparedness measures (that improve post-disaster recovery). It can be expressed as:

$$R = H/P \cdot V/M \cdot LR/PP \tag{2}$$

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

This extended risk definition has both theoretical and practical implications, as how risk is defined dictates how risk reduction is addressed (Slovic 1999). In detail, the four risk-reduction measures are:

(a) Prevention (or hazard reduction). This aims (to increase the capacity) to avoid or reduce the potential intensity and frequency of current or potential hazards that threaten households, communities and/or institutions;
(b) Mitigation. This aims (to increase the capacity) to minimize the current or potential vulnerability of households, communities and/or institutions to potential hazards or disasters;

(c) Preparedness for response (or response preparedness). This aims (to increase the capacity) to establish effective response mechanisms and structures in order for households, communities, and/or institutions to react effectively during, and in the immediate aftermath of potential hazards or disasters; and
(d) Preparedness for recovery (or recovery preparedness). This aims (to increase the capacity) to ensure that appropriate mechanisms and structures are in place to enable households, communities and/or institutions to recover following a potential hazard or disaster (including risk transfer and sharing).

These definitions highlight that, for each type of measure, there are two ways to help people to cope with, or adapt to changing climate conditions. These are: (a) direct reduction of the corresponding risk component; or (b) increasing capacities to reduce the corresponding risk component, which enables communities to reduce their risk level themselves. In both cases, the active participation of institutions and at-risk communities, as well as building upon local patterns of social behaviour and existing coping strategies has been shown to be crucial for achieving sustainable change (Wamsler 2007). The latter includes evaluating local risk reduction strategies, supporting and improving effective strategies, scaling down 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 existing and potential, but so far unused, coping strategies. The "skills and resources" mentioned in this definition translate into the four risk reduction measures, shown in Eq. 2. This means that the coping capacity of a system (or a community) is its ability to reduce overall risk by applying these measures. Although the term "adaptive capacity" is not included in the UNISDR's glossary (2009), a definition can be found in the introduction to the Intergovernmental Panel on Climate Change's Fourth Assessment Report, which states 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 given above, it can be assumed that adaptive and coping capacities are determined by the same attributes or factors. As far as this study is concerned, adaptive capacity and coping capacity are therefore synonymous, as are the processes by which they can be increased, namely, risk reduction and climate-change adaptation.

Against this background, what are the key factors that affect people's capacity to cope with, and adapt to 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 be able to safeguard their lives, property and livelihoods and recover more quickly from a disaster, although their economic losses are often greater in absolute terms (Wisner et al. 2004). In contrast, formal education is not often considered to be a key factor in people's risk levels or their capacity to cope with, and adapt to disasters. Typically, it is only linked to higher socioeconomic status and lifetime earnings (e.g. Cutter et al. 2003) or mentioned as one of many resources that people draw upon to earn their living (see models such as the Pressure and Release (PAR) Model and the "Sustainable Livelihoods" (SL) approach) (Wisner et al. 2004). In other words, these academics have argued that it is only through its correlation with income (and livelihood) that education is related to risk.

However recent studies have raised the question of whether formal education might in fact play a more central role in determining people's adaptive capacity. Three studies that combined education indicators with data from the OFDA/CRED International Disaster Database demonstrate a correlation between lower levels of formal education and a higher number of deaths or other forms of loss from disasters (independent of income). Adger et al. (2004:101) conclude that education exhibits "a strong (negative) relationship with mortality from climate related disasters." Among education proxies, the strongest indicator is the literacy rate of the population aged 15–24, followed by the literacy rate of the entire population aged over 15, and the female-to-male literacy ratio. Toya and Skidmore (2005) base their analysis on the total number of years of schooling for the population aged over 14 and demonstrate fewer disaster-related deaths and less damage per gross domestic product (GDP) in countries with more years of formal schooling. The correlation is particularly strong in developing countries, where the level of formal education proves a more significant predictor of disaster losses than income level. Using the female educational enrolment rate as an indicator, Blankespoor et al. (2010) establish that there are fewer disaster-related deaths in countries that invest in female education. In sum, these studies strongly suggest that both formal education and gender equality in education play a more determinant role in risk levels than previously thought. Nevertheless, although these studies focus on various aspects of education and risk, they do not provide a comprehensive analysis of the role of education in shaping people's risk levels. This study fills that gap.

RESULTS: FROM RISK TO CLIMATE-RELATED DISASTERS

The conceptual framework is directly linked to the research objectives of this study, which are to analyse the role of formal education in: (a) residents' risk levels, (b) their coping strategies, and (c) the institutional support they receive. According to the extended view of risk (presented in the former section), both local coping strategies and institutional support determine people's risk levels (see Eq. 2). Consequently, objectives (b) and (c) are in fact part of (a). Differences in factors that influence risk levels 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 residents' differential vulnerability, specifically the relative importance of education compared to other factors, such as income. The analyses include:

- *t*-tests to compare average levels of education and income in high- and low-risk areas.
- Cross-tabulations, χ^2 tests, and linear regression to establish whether there is a direct relationship between levels of education and income.
- Cross-tabulations and χ^2 tests to analyse the factors that determine residents' risk levels, including formal education and income.

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

- Survey data from the San Salvador case study (2009–2010);
- Survey data from the Rio case study (2010–2011);
- The institutional database of the low-income settlement *Los Manantiales* in San Salvador;
- The 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 2009–2010 survey.

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

The analysis of all four data sets show lower levels of education in high-risk households compared to residents of lower-risk areas. In other words, education and risk levels were correlated (see Tables 1 and 2). However, unlike average education levels, average income levels in the four data sets did not show any clear correlation with residents' risk levels.

Relationship between education and income

A series of cross-tabulations, χ^2 tests, and a linear regression analysis were conducted to explore the relationship between education and income. The San Salvador survey indicated no relationship between income and education. However, the 2003 *Los Manantiales* database showed a significant correlation between: (a) average educational level of residents aged over 18 and total household income ($p < 0.001$; adjusted $p < 0.05$); and (b) total household income and educational level of the head of the household ($p < 0.002$; adjusted $p < 0.10$). It was not possible to carry out a similar analysis using the information in the *Divina Providencia* database.

In the Rio case study, cross-tabulations and χ^2 tests did not show any significant correlation between education and income at the household level. However, level of education and income were significantly correlated for female residents ($p < 0.003$; adjusted $p < 0.16$). No such correlation could be found for men. In other words, it is likely that females living in this area with a higher educational level have a higher income. Although a similar analysis was not possible in San Salvador, an analysis of the data showed that the two most educated women (13 grades or more) had a higher average income (US$ 325) than men at the same educational level (US$ 207). In addition, the least-educated women earned considerably less than the least-educated men on average.

Factors influencing risk and previous disaster impact

Education and income levels were analysed in regard to the following attributes to investigate the factors that influence residents' risk levels:

- Living in a (declared) risk area;
- Self-reporting of risk (self-reporting of being at high risk);
- Impact of previous disasters;
- The use (and number) of coping strategies;
- Knowledge of existing risk factors; and
- Institutional support received.

<u>Factors influencing risk and past disaster impact</u>

Cross-tabulation and χ^2 analyses were applied to identify correlations between on the one hand, education and income levels, and on the other hand living in a (declared) risk area, self-reporting of high risk, and the impact of previous disasters.

An important finding was that the analysis of the 2003 *Los Manantiales* database showed a negative correlation between the educational level of the head of the household and self-evaluated disaster risk ($p < 0.015$; adjusted $p < 0.10$). Apart from this result, educational and income levels were not found to be significantly correlated with disaster risk or the impact of previous disasters. However, in Rio, the data indicated a possible correlation between lower mean educational levels of households and living in the *Laboriaux* high-risk area ($p < 0.005$; adjusted $p < 0.4$). In addition, in San Salvador a clear correlation was found between the impact of Hurricane Mitch in 1998 and the impact of Hurricane Stan in 2005 on the same households ($p < 0.001$; adjusted $p < 0.05$). No such analysis could be made in the Rio case study.

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

Risk	Average education of head of household (years)	Average education of household members (years)	Average income of head of household (US$ / BRL[a])	Total income of household (US$ / BRL[a])	Household income per person (US$ / BRL[a])
San Salvador case study					
High	5.0	6.2 [b]	111	243	57
Low	5.7	7.0 [c]	71	259	59
Rio case study					
High	5.6	6.5	818 (≈US$ 485)	1258 (≈US$ 746)	442 (≈US$ 262)
Low	7.0	7.1	801 (≈US$ 475)	1478 (≈US$ 876)	568 (≈US$ 278)

[a] Brazilian Real [b] If only those who receive income are included, the average is 6.5 [c] If only those who receive income are included, the average is 7.3

Factors influencing people's way of coping

Cross-tabulations were used to assess whether coping strategies are influenced by level of education, income, and/or the impacts of past disasters.

The San Salvador case study did not show any significant correlation between education or income and (conscious) strategies adopted to cope with and adapt to disaster risk. However, there was a significant correlation between the impacts of past disasters and the use of coping strategies ($p < 0.001$; adjusted $p < 0.05$). In other words, households that had been most affected in the past were most likely to take their own risk-reduction measures (76.9% for Hurricane Mitch; 88.2% for Hurricane Stan).

Based on the assumption that risk awareness is a precondition for taking risk-reducing measures, in the Rio case study education level was tested against residents' ability to identify risks affecting the settlement. The correlation that emerged ($p < 0.00013$; adjusted $p < 0.0104$) was the most significant result from the Rio case study. This indicates that interviewees with lower levels of education were more likely to see their surroundings as risk free, whereas those with higher levels of education were more aware of existing risks. Moreover, interviewees with a higher level of education were able to name more risks affecting the settlement ($p < 0.003$; adjusted $p < 0.16$). A similar comparison could not be made with the data from the San Salvador case study.

Factors influencing institutional support

A series of cross-tabulations were used to assess whether education, income, and/or the impacts of past disasters influence the institutional support households receive to cope with and adapt to disasters. No significant correlations were found. However, the data showed that in both case studies high-risk families received more institutional help than those at lower risk. Despite this support, 36% of families in San Salvador and 63.3% in Rio stated that their current level of risk was similar or higher than before. Further analyses suggested a correlation between the ability of households to express being at risk and having received institutional support. For example, with a 40% error rate, a potential correlation was found in *Rocinha* between self-reporting of being at risk and receipt of institutional help ($p < 0.005$; adjusted $p < 0.4$).

Qualitative Analysis of Risk Factors: Differential Vulnerability

This section presents the results of the qualitative analyses of factors that influence people's differential vulnerability. They show how disasters affect residents living in informal settlements such as *Los Manantiales* and *Rocinha,* and how this relates to their level of formal education. Unlike the quantitative analyses presented in the previous section, the qualitative analyses do not investigate the relative importance of education (compared to factors such as income), but instead provide illustrative examples of how education can influence residents' level of disaster risk. This section thus provides an understanding of *how* education is linked to the conceptual framework presented earlier.

Education: direct effects on risk-reduction

In both the San Salvador and the Rio case studies, results showed that education has a direct influence on residents' risk level and associated risk reduction. A comparison of data obtained from interviews, observation and relevant literature showed that formal education can have a positive effect on:

- Awareness and understanding of existing risk;
- Access to (and provision of) information on risk reduction;
- Acceptance and adequate use of institutional support; and
- Coping strategies (i.e. improvements to residents' risk-reduction strategies).

The following sections describe these outcomes in more detail.

Table 2. Average education and income levels in focus and control groups (i.e., residents 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

Awareness and understanding of existing risk

The quantitative analyses of the Rio case study showed a correlation between level of education and ability to perceive existing risks (see previous section). Interviews with key informants and residents confirmed this result. For example, a representative of the Rio de Janeiro Civil Defence Service stated that formal education is "directly linked to people's ability to perceive risks." As risk awareness is a necessary condition to engage in disaster risk reduction (UNISDR 2002), this demonstrates the vital role of education in increasing people's adaptive capacity.

In the San Salvador case study, upon probing, virtually all (97%) high-risk interviewees named either flooding or landslides as an imminent risk to their lives, and the majority (83% of the focus group) mentioned at least one factor that makes them more vulnerable than other, lower-risk residents (Wamsler 2007). However, and like the Rio study, the qualitative analysis of the 2006 interviews showed that it was high-risk illiterate interviewees who were unable to mention any additional risk factors.

Access to (and provision of) risk-reduction information

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 access to information such as:

- Hazards and other threats;
- Safer places to live;
- Risk-reduction measures;
- Potential institutional support; and
- Laws and resident's rights.

As an example, Ana, a highly-educated female *Rocinha* resident, mentioned searching for risk information on the internet as one of her main coping strategies (see Box 1). Other *Rocinha* residents suggested that better-educated residents are generally better able to express themselves, which is crucial in informing others (including authorities) about their risk situation. Similarly, key informants stated that residents with higher levels of education are more likely to be successful in their contacts with authorities and emergency officials. This was confirmed in the San Salvador case study, where those residents with the lowest levels of education were also those who frequently mentioned that: (a) they have no idea how to improve their situation; and (b) they do not know of any institutions that could assist them.

Acceptance and adequate use of institutional support

Both case studies suggest that residents with higher levels of education are more likely to respond to disaster warnings and alerts (Cutter et al. 2003, Lindell and Perry 2004). The Rio de Janeiro Civil Defence Service noted that one of the

Box 1. Education and access to risk reduction information

Ana, a 40 year-old single mother with 11 years of education is taking university-entry exams to study journalism. She lives in *Cachopa*. Although she has not received any institutional support to improve her situation, she has succeeded in receiving a stipend from the renowned private language school *Cultura Inglesa* for her son to study English. When asked about how she copes with existing disaster risk, she mentions a range of strategies including:

- Looking for risk information on the internet;
- Investing in the structure of the house;
- Improving the electricity (distribution and outlets);
- Not throwing rubbish in the streets;
- Staying informed about how to prevent diseases like dengue and tuberculosis;
- Avoiding hazardous areas during emergencies (such as a nearby gas station);
- Sending her son to swimming lessons; and
- Sending her son to study outside the *favela* (slum).

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

main explanations for differential vulnerability within communities is that warnings and alerts are ignored by some residents. A community worker in *Rocinha* supports this, stating that education makes residents less suspicious of authorities and more likely to accept institutional support. No such clear correlation was found in the San Salvador case study. However, interviews and observation suggest that education level (and not income) influence adequate use of institutional assistance (see Box 2). Adequate use of institutional assistance refers to the active participation of residents, long-term maintenance of physical risk-reduction measures, regular contributions to established local emergency funds and appropriate use of credits.

Improvements to coping strategies

In both study areas, after probing only around 65% of interviewees mentioned any risk-reduction strategies or improvements. However, observation and interviews with key informants show that virtually all residents of *Los Manantiales* and *Rocinha* are, as in many southern low-income settlements, actively adapting to their risk situation (Wisner et al. 2004, 2007, Jabeen et al. 2009). Strategies residents are aware of, and thus are consciously applied are mainly structural or economic (e.g. home improvements or use of credit). The study shows that it is mainly interviewees with a higher level of education who mention and actively use other strategies. These include strategies directly related to education, such as:

- Temporarily or permanently sending children to study outside the settlement (see Box 3);
- Improving access to schools (e.g. paving streets or building bridges);
- Encouraging dependents to study;
- Taking jobs outside the settlement;
- Being able to change employers (e.g. in response to demand influenced by climate variability and extremes); and
- Staying informed of existing risk (from different sources).

The data analyses suggest that it is not necessarily the number of strategies, but the use of different strategies that characterises residents with different educational levels. The use of different strategies increases the likelihood to tackle several risk components (i.e. hazards, vulnerabilities, and response and recovery mechanisms).The qualitative analysis also shows that, unlike education, increased income often leads to a greater number of, or stronger focus on, physical improvements, which does not necessarily lead to reduced risk (Wamsler 2007). Moreover, better-off households are more likely to opt out of community engagement. This can have a negative effect on social cohesion and the disaster resilience of the entire community (Wamsler 2007).

Finally, two education-related issues were identified to be particularly relevant to efficient local coping: formal employment and interest in moving to a lower-risk area (within or outside the settlement). The following subsections explain how these two issues reduce risk and how they relate to education levels.

Formal employment

Neither the San Salvador nor the Rio case study indicate a strong correlation between formal education and income. However, both studies show the importance of formal employment in coping with disasters. In fact, helping dependents to find formal employment was mentioned as a coping strategy (Wamsler 2007). Interviewees stated that formal employment allows them easier or cheaper access to:

Box 2. Education and institutional support

Francisca lives with her husband and baby in the high-risk *Laboriaux* area. She is 26 years old and has eight years of education. When asked how she copes with the imminent risk of landslides, she mentions a range of strategies, including staying at home to not miss information from the Civil Defence Service.

Maria, a female *Los Manantiales* resident with six years of education, takes an active part in the community-based work offered by the FUNDASAL institution to reduce existing risk. Although several other interviewees were reluctant 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 government-sponsored programme *Programa de Aceleração do Crescimento* describes the importance of education: "After 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, residents' education is certainly a determinant [for their level of risk]."

Box 3. Education and coping mechanisms: Education as a conscious strategy

Ana, a single mother with 11 years of education, lives in *Cachopa*. One way she deals with risk is to send her son to study outside the *favela* so that his education is not affected by problems such as natural hazards, shootings, power cuts, and teacher strikes. In contrast, Francisca, a single mother with eight years of education, living in *Laboriaux* sent her two eldest sons to the local school. However, after the devastating landslide in 2010 and the closure of the local school, she decided to send them to stay with her mother who lives in another state. For Francisca, this is an active coping strategy as she does not want her boys to miss school and she is afraid that she would not be able to save both her two boys and her baby if there was another landslide.

- Post-disaster credits;
- Life insurance;
- Retirement pension or incapacity benefit;
- A regular income (e.g. work that is not vulnerable to climate variables and extremes);
- Health insurance;
- Sick leave (e.g. following a disaster);
- Other benefits (e.g. regulated hourly rates, safe working conditions due to formal security regulations);
- Direct post-disaster assistance from employers; and
- An official address (the employer's), which is 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 local entrepreneurs who certify his employment, thus giving him (illegal) access to formal insurance mechanisms. In addition, residents working in the informal sector often hold several jobs and have little time for community-based risk-reduction efforts (Wamsler 2007). Finally, interviewees suggested that a certain level of education is a determinant for finding formal employment (see Box 4), and that there is less likely to be a correlation between formal education and income for male residents. This may relate to the fact that there are generally more well-paid jobs for men (than women) that do not require any formal education.

Moving to a lower-risk area

Although the quality of education in low-income settlements in San Salvador and Rio is often substandard, this study suggests that education may be key to moving to a safer area. This includes lower-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. Better-educated interviewees tended to see moving elsewhere as an option and had ideas about how to achieve it. In a study of Rio's informal settlements, Perlman (2010) found three factors that increase the likelihood of a move from the *favela* (slum) to a *bairro* (formal settlement). Those who moved tended to: (a) have better-educated fathers; (b) have a higher level of education themselves; and (c) be more knowledgeable about Brazilian politics. In contrast, no correlation was found between leaving the *favela* and income level. The same study shows that *staying* in an informal settlement is, however, correlated with other well-being indicators, such as being in formal employment, being a homeowner, and/or being active in a community organization (Perlman 2010). Interestingly, in San Salvador all interviewees with an exceptionally high level of education and a formal job (at a governmental agency) had moved to a lower-risk area within the settlement. Finally, both the San Salvador and the Rio case studies demonstrate the importance of women as the driving force behind families moving out, typically motivated by their wish to protect their children (see Box 5).

Education: mitigating effects on risk factors

Both the San Salvador and the Rio case studies found that higher levels of education can reduce underlying risk factors. Underlying risk factors include:

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

The findings presented below describe: (a) the relevance of the factor in the context of the case study areas; (b) its relationship to education; and (c) its influence on disaster risk. They illustrate how education can have a mitigating effect on underlying risk factors, how this is linked to the conceptual framework presented earlier and how the various factors are mutually reinforcing.

Box 4. Education, formal employment and disaster risk

"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 the *Rocinha* Residents' Association, education levels influence disaster risk levels in two ways: (1) less education generally leads to a greater number of children per family; and (2) it restricts access to formal employment. 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 residents incapable of moving out [of the risk zone] and to a better place."

In *Cecilio del Valle*, Mercedes describes her uncle who recently died leaving four children. As he had formal employment, she now receives 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."

Box 5. Education and moving to lower-risk areas

Esperanza, who lives in the *Los Manantiales* area, has always wanted to leave in order to protect her children. However, her husband's unwillingness to move created 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." In the end, Esperanza stayed in *Los Manantiales* as risk levels were considerably reduced with the help of FUNDASAL's slum upgrading program.

Poor health

Context: The physical and mental health of residents in the *Los Manantiales* and *Rocinha* areas is poor compared to the surrounding formal settlements. The high number of health problems is partly caused by a lack of waste and waste-water facilities, contaminated wells, overcrowding, violence and poorly-ventilated houses (Verly 2009) as well as by informal and physically demanding work.

Education→poor health: Education levels are an important determinant of health. The number of years of schooling has been shown to be the second most influential variable on the health status of adult Brazilians (after age) (Fonseca et al. 2000). Disease is exacerbated by a failure to follow treatment regimes, which is directly related to poor education (Ferreira et al. 2005). Furthermore, interviews revealed that many of the less well-educated residents of *Los Manantiales* and *Rocinha* are forced to take informal jobs, which are often physically demanding, with unregulated working hours, little attention given to workers' health and safety and no health insurance—leading to injuries, physical wear and tear and mental stress.

Poor health→disaster risk: Good health is a key resource for disaster survival (Enarson 2000, Wisner et al. 2004), while poor health makes people more vulnerable. As Box 6 shows, poor health makes it more difficult to earn a living and can force other family members to leave school to support their family. The interviews suggest that some health conditions (for example being disabled or HIV-positive) increase vulnerability by adding to the stigma of living in a low-income area. Furthermore, health is a determinant of people's capacity to respond to disasters. Limited mobility makes it difficult to navigate steep stairways and winding alleyways in an emergency (see Box 6). Poor health is also likely to affect capacity to recover from a disaster. It is, for instance, more difficult to withstand infectious diseases that often spread in the aftermath of disasters with an already weakened immune system (Wisner et al. 2004). An illustrative example is a woman who lives in the high-risk *Laboriaux* area. Although she did not suffer directly from the landslide in 2010, her history of psychological illness meant that the landslide had a serious impact on her, and she had great difficulty returning to her previous life.

Organized crime (and corruption)

Context: The residents of *Los Manantiales* and, to a greater extent, in *Rocinha* have been abandoned by regular law enforcement agencies and rely on gangs to keep order. In the San Salvador case study, flooding and landslides are generally seen as the main risk to lives and livelihoods. These are followed by earthquakes and windstorms, a lack of job opportunities and insecurity created by *maras* (gangs). *Los Manantiales* residents are killed, harassed, violated and robbed on a daily basis (FUNDASAL 2010). In the Rio case study, the most frequently mentioned risk after landslides was being caught in crossfire during one of the police's sporadic raids in their effort to control violent gangs.

Education→organized crime: Primary and secondary education has been shown to be one of the most effective ways to sustainably reduce participation in the drug industry (Dowdney 2003). In San Salvador, community leaders explicitly mentioned the direct relationship between poor education and violent behaviour, in the form of organized crime and intra-family violence. In addition both case studies show that children who drop out of school are more easily recruited by criminal gangs (Dowdney 2003, FUNDASAL 2010), and young men with little education often see no other way to make a sustainable living than to work for traffickers (Dowdney 2003). Lack of access to the employment market for youngsters from informal settlements is another factor that contributes to the steady flow of new recruits into criminal gangs (Perlman 2010, FUNDASAL 2010).

Box 6. Education and poor health

Claudia, a less-educated female resident of *Los Manantiales* suffers from a kidney malfunction. Before falling ill, Claudia earned a living from informal cleaning work in households outside the settlement. During an interview, she described how a lack of health insurance and consequently difficulty in accessing health services caused her health to deteriorate and 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 has just finished his third year at school. His mother's poor health and the family's resulting financial difficulties mean that he is forced to leave school to earn money for her and his family. Although his mother is not happy about this, 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 next to the river all his life, but now he is worried because he lost his leg in a work accident and then lost his wheelchair (which had been given to him by a church) during the floods in the aftermath of Hurricane Stan. He 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." Ernesto lost not only his wheelchair, but also his house and his land during Hurricane Stan, and he is thus currently living on his neighbour's land. His own son had to leave school and is unable to work because he has to take care of his handicapped father.

Organized crime→disaster risk: Violent conflicts between gangs and the police mean that life expectancy for men is low. 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 local risk-reduction efforts (Wamsler 2007). In addition, organized crime, corruption and political factionalism have eroded trust and social capital within informal settlements, affecting community cohesion and community-based coping mechanisms (Wamsler 2007). They also dilute the flow of information about jobs and other opportunities, which is spread through informal community networks (Perlman 2010). This included information on potential risk-reduction measures and institutional support. In Rio, many residents' associations have been threatened or taken over by drug gangs; consequently participation in community organizations has drastically decreased (Perlman 2010). However, observations and interviews show that in both case study areas communities are highly dependent on mutual help. The loss of social capital due to organized crime therefore appears to have serious effects on risk levels. In addition, organized drug trafficking can lead to the increased availability and abuse of illegal substances and thus higher risk levels (Uchtenhagen 2004, National Institute on Drug Abuse (NIDA) 2010). Interviewees described drug trafficking, drug abuse and associated violence as a threat to both health and well-being, which results from increased mortality and psychological stress (cf Uchtenhagen 2004, Box 7).

Teenage pregnancy (and single motherhood)

Context: There is a high rate of teenage and pre-teenage pregnancies in the case study areas. In off-the-record discussions about risk, early pregnancies are mentioned almost as frequently as drug trafficking.

Teenage pregnancy and education: 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 are some indications that the risk is higher for teenage girls who do not attend 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 disaster vulnerability. These include higher expenses, difficulty in continuing education or income-earning activities, health complications during and after pregnancy, and potential rejection by their family or partner. Interviews and observations show that early and unplanned pregnancies often create vulnerable family units (e.g. single-head households) and add to the responsibilities of the parents of the young (or single) mother. Disaster literature shows that mothers (and to an even greater extent single mothers) are at particular risk in disaster situations (Enarson 2000, Cutter et al. 2003). Being responsible for a small child (or several) can affect a woman's ability to cope with and respond to disasters (see Box 8).

Informal settlement growth

Context: Amidst all the difficulties of life in *Los Manantiales* and *Rocinha*, there is great ingenuity. Materials and objects are constantly sold and repurposed for the construction of housing, microenterprises or risk reduction. Old car tyres are converted into retaining walls or embankments; plastic sheets and corrugated iron are turned into gutters. Problems such as a lack of living space are solved by the construction of another floor or expansion along river banks, a lack of electrical sockets is fixed by simply pulling another cable, and many residents work informally in various sectors. However, there is a downside

Box 7. Education, organized crime and corruption

Several interviewees describe how rivalries between groups (political parties or violent gangs) combined with corruption, has a negative influence on the institutional support available. Luis, living in *Cecilio del Valle,* states: "The retention walls were probably built in the least-affected areas, and residents 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 residents, including the local board members, 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 highlights the influence of politics on not only local assistance (from the local committee), but also the municipality: "Well, this is how the political parties work [...]: it is only some few residents who really get some help [...], they give corrugated iron sheets, scantlings, cement or bricks [...], but they only give to some."

Box 8. Education and teenage pregnancy

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: "Residents 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 residents' 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 of a burden, so that they cannot continue going to school."

to this rapid informal development. Overcrowding, unsafe construction, the absence of waste and water management, the permanent fear of eviction, deforestation and excavated slopes are part of daily life.

Education→informal settlement growth: Formal education may be a determining factor in improving prospects for moving to a formal part of the city, where risk and risk reduction are less shaped by informal processes. In addition, the poor quality of public education in El Salvador and Brazil particularly affects children living in informal settlements (see the following subsection), which amplifies differences and inequalities between residents living under "formal" and "informal" conditions.

Informal settlement growth→disaster risk: The impact of informal settlement growth on disaster risk relates to aspects such as stigmatization, exclusion from formal decision-making processes, insecure tenure, and inadequate housing and infrastructure. Findings from both study areas show that living in an informal settlement limits opportunities to find employment or access institutional assistance (see Box 9). Living under informal conditions often means not having an official address (Censo Domiciliar 2010) which restricts access to education (an address is required to register children at school) and participation in formal decision-making processes (Perlman 2010, UN-HABITAT 2010). Many residents of informal settlements further have to deal with constant fear of eviction, which reduces any motivation to improve their risk situation (Wamsler 2007). In addition, informal building processes result in housing and infrastructure that cannot resist hazard impacts, create additional hazards, and obstruct disaster response and recovery (see Box 10). In terms of recovery structures and mechanisms, access is problematic for residents who do not have legal tenure and informal workers who lack associated rights.

Disaster impacts on people's education

Both the San Salvador and the Rio case studies show that disasters strongly affect residents' lives and livelihoods, which includes short- and long-term impacts on their level and quality of education. In particular, in the aftermath of disasters children are often obliged to temporarily or permanently leave school. The reasons for this include:

- They have to work to support their family;
- They have to take care of injured family members (see Box 6);
- There is no money to pay school fees (due to post-disaster expenses or theft from damaged and easily accessible houses);
- The loss of belongings required to attend (or change) school (school uniforms, books, identification, etc.);
- The destruction of the local school; and
- The permanent closure of the local school due to its location in a (newly declared) high-risk zone.

Box 9. Education, informal settlement growth and stigmatization

Eugenio from *Rocinha* says that the *favela*'s reputation as a violent and lawless area creates mistrust in its residents, even though most are victims rather than the perpetrators of crime. Not only does this stigmatization make it difficult for him to find formal work, he cannot reach his job during shootouts between traffickers and the police without risking his life, adding further weight to his employers' discrimination.

In San Salvador, interviewees from *Cecilio del Valle* describe how government officials are completely unaware of 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."

Stigmatization due to an address (i.e. the name of the settlement) is illustrated by Alejandro, a 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 as a result of the FUNDASAL slum upgrading project (which provided assistance land regularisation and help with physical risk-reduction improvements) that they were given legal tenure.

Box 10. Education, informal settlement growth and insecure tenure

The examples of Maria, living in *Laboriaux* (Rio), and Eugenia living in *Cecilio del Valle* (San Salvador), demonstrate the importance of legal tenure. 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 were awarded a scholarship by the church to study. When asked about how she copes with risk, she mentions being a homeowner (as opposed to renting) as a strategy, and investing in improvements to her house and land in order to reduce disaster vulnerability. As she earns her living informally through a local catering business, she does not want to move elsewhere. In fact, she considers *Rocinha* to be the perfect place to live and run a catering business, because its central location makes it easy to attend to clients from wealthier areas (*São Conrado* and *Ipanema)*. She says that where she lives benefits from a big kitchen, natural springs with fresh water and a marvellous view. The only problem is that local disasters negatively affect her business. After the disaster-related deaths in 2010 in *Laboriaux,* residents were not in a *clima de festa* (party mood). Residents moved away from *Laboriaux* and local demand for her birthday cakes and party catering fell.

In other cases, although children do not have to leave school, they must temporarily or permanently travel to another, more distant school. This results in:

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

Sometimes families have to move to other areas where their children cannot 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 female residents highlighted that in the aftermath of a disaster there are many factors that make it difficult for children to concentrate on their studies. Such factors are:

- Reduced or lack of space for studying as houses are damaged or destroyed;
- Electricity failure or outages, making it impossible to study in the early morning or after sunset;
- Difficult and dangerous routes to school;
- Community distress;
- Psychological distress of families;
- Pupils have increased responsibilities such as taking care of sick family members, reconstruction of houses, part-time jobs, etc.;
- Living in temporary shelter or in unsafe houses with no privacy (no doors, walls, etc.);
- Family disruption due to a permanent move of (some of the) children to other family members living in safer areas; and
- Increased health problems that have disproportionate effects on young schoolchildren.

With education being crucial to adaptive capacity, disasters and their impact on education are likely to result in a vicious circle of increased risk and deteriorating education. However, it is important to highlight that education in low-income settlements is inadequate even when disasters do not occur. Classes are often cancelled due to power cuts, shootings, and absent or striking teachers. Not many teachers want to work in a slum; not only because they consider it unsafe, but also because such places have little social value (Gonçalves 2010, Perlman 2010). Nevertheless, although the quality of education in both case study areas is obviously low (and has even declined in some parts), several interviewees mentioned that the improving access to education for their children in recent years is a reason why they feel less at risk.

DISCUSSION: TOWARD SUSTAINABLE ADAPTATION

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

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

The initial evidence suggested that education does not play a major role in disaster risk levels. All the international risk management experts interviewed suggested that education plays only a minor role for risk reduction, which is based on its potential influence on income levels. In addition, none of the international or national experts who were consulted were aware of research that specifically analysed links between education level and disaster risk, nor of any databases that would permit such analyses. Nevertheless, the in-depth comparison of the quantitative and qualitative data showed a different picture. In fact, the qualitative results of both the San Salvador and Rio case studies indicated that formal education has a positive and direct effect on:

- Awareness and understanding of existing risk;
- Access to, and provision of information on risk reduction;
- Acceptance and adequate use of institutional support; and
- Improvements in residents' coping strategies.

As regards the latter, two issues related to formal education were particularly relevant to local coping: formal employment and interest and efforts made to move to a lower-risk area within or outside the settlement. In addition, the qualitative results suggest that a higher level of education mitigates underlying risk factors. These factors include:

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

The quantitative analyses support some of the qualitative results. For example, they indicated a significant correlation between:

- Level of education and ability to identify risks (Rio);
- Level of education and number of risks identified (Rio); and
- Lower (higher) average education level and living in a high (low) risk area (San Salvador and Rio).

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

- Households affected by Hurricane Mitch in 1998 and those affected by Hurricane Stan in 2005 (San Salvador);
- The impact of past disasters and local coping strategies (San Salvador); and
- Women's level of education and income (Rio).

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

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

Comparative Analysis:
The Climate/Education Nexus

The above summary of the key results shows that education has both a direct and indirect influence on residents' disaster risk level. This section highlights some of the differences between the two case studies.

Education and disaster risk

The Rio case study showed a clear statistical correlation between educational levels and ability to identify risks in the settlement. This result was independently confirmed in interviews with key informants and showed that less-educated residents tend to downplay risks. Assuming this is the case, the analysis of the 2003 San Salvador database, which identified a negative correlation between education and disaster risk, becomes more significant than it first appears. In this dataset, high and low risk is self-defined (unlike more objective risk evaluations). It also reflects the situation in the settlement before the FUNDASAL slum upgrading program and related risk-awareness campaigns. Consequently, the correlation could be even stronger than it seems (assuming the positive influence of education on the adequate use of institutional support). Interestingly, a more detailed analysis of the same database showed a correlation between both education and disaster risk, and between education and income, but *not* between income and disaster risk. This demonstrates the importance of education rather than income. Likewise, the Rio case study showed no significant correlation between education and income, either for households or for men—although the situation was different for women (see below).

A comparison of the qualitative and quantitative results of the San Salvador case study suggests that there is an important link between education levels and risk-reduction coping strategies. This correlation was not significant in the quantitative analysis, and this is probably due to the fact that the analysis was only based on coping strategies mentioned by interviewees (therefore those they are aware of). However, conscious coping strategies tend to be related to structural or economic improvements (Wamsler 2007), which overlooks the numerous other strategies that were identified in the qualitative analysis.

Institutional support for risk reduction and adaptation

The case studies suggest that current levels of institutional assistance in reducing and adapting to risk are insufficient. Although in San Salvador high-risk households received more assistance than those at moderate risk they were nevertheless similarly affected by the impact of both Hurricane Mitch in 1998 and Hurricane Stan in 2005. A similar analysis could not be made in the Rio case study. However, in the Rio study, although at-risk households had received more institutional help, 63.3% of them still stated that their current level of risk is similar or even worse than before. In addition, virtually all interviewees agreed that current measures are not sufficient to cope with increasingly frequent disasters, which casts doubt on current institutional approaches.

The "gender twist"

The study found that formal education seems to have a particular impact on women's level of risk. This was confirmed by the statistical analyses of the Rio case study and the qualitative results of both case studies. The analyses show that, for women, better education is likely to lead to a higher income. No such correlation was found for 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 generally not the case for female-dominated jobs. In addition, it seems that it is easier for men (rather than women) to find formal employment without a certain level of formal education. Given the importance of the influence of formal employment on adaptive capacity (as demonstrated in the "Results" section), formal education is a key determinant of women's risk levels.

The importance of formal education in determining women's risk levels becomes also obvious when analysing other qualitative outcomes. In fact, the results show an obvious "gender twist", in that correlations between education and the factors that (directly or indirectly) influence risk are more (or only) relevant to women. Obvious examples include teenage pregnancy and single motherhood. Health is another factor where women's level of education is especially determinant, and the correlation between education and HIV/AIDS in Brazil is one of many examples (Fonseca et al. 2000). With regard to organized crime and substance abuse there

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

Factors influencing people's level of risk	Influence of (lower levels of) education *Illustrative examples of how lower levels of education might increase risk*	
Hazard(s)	Increased exposure to existing hazards due to high and increasing numbers of residents in the same disaster-prone settlement with no option or little interest in moving to lower risk areas, resulting in: • Increased proximity of housing and infrastructure to hazards • Expansion of informal settlements into high-risk areas	Intensified hazards and creation of new ones, such as: • Floods related to extensive littering and inadequate infrastructure • Landslides due to excavation, deforestation, intensive littering, and inadequate construction • Fire due to inadequate electricity connections
Vulnerability	• Concentration of highly defenceless population groups weakened by diseases, conflict, work-related injuries, family disruptions, etc. • Organized crime and corruption affecting community cohesion and information flow on risk and risk reduction • High numbers of teenage pregnancies and vulnerable households with single mothers, numerous children, or other dependents, etc.	• High numbers of residents working in informal and physically demanding jobs with no or little social protection • Limited access to formal assistance and low influence on decision-making processes (for risk management) • Inadequate housing construction and infrastructure • Mistrust in authorities, including planning authorities and emergency organizations
Response mechanisms and structures	• Reduced mobility of residents with poor health, single mothers, and families with many children • Reduced mobility due to low income (e.g., no personal vehicle and lack of money to pay for public transportation) • Reduced mobility due to organized crime (resulting in high levels of insecurity and increased expenses for "protection" offered by criminal groups)	• Lack of emergency access and evacuation roads (due to informal living conditions) • Limited access to formal response mechanisms (due to informal living conditions) • Mistrust in authorities and thus ignorance of formal disaster warnings, alerts, evacuations, emergency shelter, etc. • Difficulties in communication and contact with emergency organizations
Recovery mechanism and structures	• Difficulty recovering quickly due to poor health conditions • 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.)	• Mistrust in authorities (which might lead to refusal or inadequate use of recovery assistance offered)

is a similar "gender twist." Although it is mainly men who are directly involved, women have to bear most risk-increasing consequences.

Finally, it is important to highlight the role of women in actively reducing risk. Women are often motivated by a strong desire to protect their children or to provide them with better opportunities, including improved education.

From Current Risk Reduction to Sustainable Adaptation

The identified strong influence of formal education on risk and risk reduction can be described by linking the results to the extended risk definition presented earlier. The conceptual and practical implications are presented in the following section.

Conceptual implications of results

The conceptual framework presented earlier proved to be an appropriate tool for the analysis of the influence of formal education. Unlike the conventional view of risk, it makes it possible to carry out a comprehensive analysis of interactions between education, disaster risk, risk reduction and adaptive capacity. People's risk levels are here determined by four risk factors: existing local hazard(s), vulnerabilities, and response and recovery mechanisms. Associated measures or adaptive capacities that aim to reduce the four risk factors are: prevention, mitigation, preparedness for response, and preparedness for recovery. This study shows that education has an influence on all risk factors and the respective 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 *Illustrative examples of how higher levels of education might reduce risk*	
Precondition for adequate selection of adaptation measures	• Increased risk awareness • Better access to information on risk, risk reduction, available institutional assistance, etc. • Greater ability to assess, and provide authorities with information on, own risk situation	• Increased acceptance of (adequate) institutional assistance • A certain level of community cohesion, good health, time availability, and financial resources
Prevention	• Moving out of a risk area (within own settlement or outside own settlement)	
Mitigation	• Use of an increased number of risk reduction measures, including non-structural measures • More active use of education-related coping strategies, such as sending children to study outside their own settlement	• Better use of institutional assistance (e.g., through the adequate use and maintenance of constructive measures) • Better selection of adequate risk reduction measures
Preparedness for response	• Acceptance and adequate use of institutional support such as warnings, evacuation, emergency shelter • Active use of education-related coping strategies, such as temporarily sending children to study outside their own settlement	• Increased mobility
Preparedness for recovery	• Improved access to post-disaster credits, life insurance, paid sick leave, pension, etc. (due to formal jobs)	• Better use of institutional support such as recovery credits

CONCLUSIONS

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

This paper examines the influence of formal education on the adaptive capacity of 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 frequent. The research explores the promotion of formal education as a way to increase adaptive capacity. Data was collected using interviews, surveys, a literature review and observation, and both quantitative and qualitative data analyses were applied. Statistical analyses investigate the influence of formal education on residents' risk levels, coping strategies and institutional support. The qualitative analyses explore both the 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 risk levels and adaptive capacity than has hitherto been acknowledged. In both case study areas, the average level of education was lower in high-risk households (as opposed to lower-risk households). The positive influence of education was identified to be twofold: (a) it has a direct effect on risk-reducing factors; and (b) it mitigates factors that increase risk. On the one hand, formal education has a positive effect on issues such as levels of awareness and understanding of risks; access to information on (the adequate use of) risk-reduction measures; opportunities to find formal employment; and interest in moving out of an at-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. The latter includes the stigmatization of slum dwellers, exclusion from formal decision-making processes, insecure tenure, and poor housing and infrastructure. The results suggest that education plays a more determinant role for women than men in terms of adaptive capacity. They indicate that the identified limited effectiveness of institutional support for risk reduction may be related to the fact that the role of formal education has not been sufficiently explored.

Although further research is needed to test the validity of the findings in different contexts, they can justify the promotion of (improved access to and quality of) formal education as a way to increase adaptive capacity—and not only because of a potential influence on income. This outcome is supported by the negative impact of disasters on education, which in turn reduces adaptive capacity, resulting in a vicious circle of increased risk. A strong testimony in this context comes from

children themselves. In a recent study interviewing more than 600 children in Africa, Asia and Latin America, education was, in fact, the most commonly occurring theme and prioritised by all children during the consultations. Common requests were for their schools to be built on higher ground, for their learning materials to be protected, and for roads and bridges to be maintained to guarantee a safe way to school also during rainy periods (UNICEF 2011).

The strength of an education-based adaptation approach lies also in the fact that formal education was shown to influence all four risk components and related adaptive capacities without predetermining, specific or inflexible risk-reduction measures. In this context, formal education was a particularly crucial factor in the capacity to recover as it helps people to bounce back from the impact of a disaster by quickly (re)establishing livelihoods. Finally, the conceptual framework proved to be an appropriate analytical and practical tool that may help strengthen current planning strategies for investment in climate change adaptation.

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