35 Measuring vulnerability to climate change for allocating funds to adaptation

Patrick Guillaumont
Ferdi

The debates on financing adaptation to climate change have so far not really addressed its allocation across developing countries. This chapter examines how the concessional funds for adaptation should be allocated. The principle proposed is a 'vulnerability-based allocation' (VBA) whereby funds are allocated to developing countries primarily according to their vulnerability to climate change, for which they are not responsible. To this end, a physical vulnerability to climate change index (PVCCI) is proposed, as tentatively established by Ferdi, which aggregates the physical impacts of climate change according to their main identifiable channels. The index is likely to be updated regularly. Its average level is given for some groups of countries, such as LDCs and SIDS. To determine the allocation of adaptation funds, the index should be used in a simple formula that also includes income per head, since the poorer countries are, the less resilient they are to climate change. The choice of the parameters of the formula will express, in a transparent way, the consensus of the international community on the principles of the allocation of 'adaptation credits' by country. A tentative simulation shows the relative share that each group of countries would receive (with more than half going to LDCs), as well as the ratios of the level of allocation per head to the average for developing countries (which are high for SIDS and for LDCs). Adaptation credits could be used by countries via accredited financial institutions to which they would submit their adaptation programs or projects.

1 Introduction: The geographical allocation of adaptation funds within 'climate finance'

The discussions on financing the responses to climate change in developing countries too often mingle separate issues. Indeed, adaptation to climate change cannot be dissociated from economic development, or be designed regardless of mitigation of climate change, which is itself essential in development strategy. But these interactions are at the operational level. They do not negate the need to distinguish between the respective sources of funding available for development, adaptation and mitigation, in particular between the respective concessional sources, and their justification.

Two problems arise in financing each of these three purposes: first, the mobilisation of resources; and second, their allocation among recipient countries. The mobilisation of resources has so far held much more of the attention of negotiators and experts than their allocation (Brender and Jacquet 2015, Canfin and Granjean 2015; Westphal et al. 2015). The final declaration of the July 2015 UN Conference on Financing for Development (held in Addis Ababa) is revealing in this regard. Concerning climate finance, it recalls the commitment of developed countries to mobilise US$100 billion per year from 2020 "from a wide variety of sources to address the needs of developing countries", as well as the need for transparent methods of reporting climate finance (United Nations 2015, para. 60). It welcomes the implementation of the Green Climate Fund (GCF) and the decision of its Board "to aim for a 50:50 balance between mitigation and adaptation over time on a grant equivalent basis and to aim for a floor of 50 per cent of the adaptation allocation for particularly vulnerable countries, including least developed countries, small island developing States and African countries "(United Nations 2015, para. 61). The rule to be used for sharing of the GCF between adaptation and mitigation has not yet been decided for the remaining and major part of the $100 billion; the same holds for the aim of a minimum of half to go to vulnerable countries.

It is assumed here that the total amount of climate resources mobilised for developing countries is a given (see the chapters by Buchner and Wilkinson and Massetti in this book), as well as the sharing of these resources between mitigation and adaptation. It is also assumed that it has been decided that the share will be provided in a concessional

manner, and that concessional resources will be additional to those already mobilised for development.

Using these assumptions, we examine how concessional resources for adaptation should be allocated among developing countries. This chapter first presents the principles the allocation should meet, and stresses the need to take into account the vulnerability to climate change of each country (Section 2). Section 3 discusses the nature of the vulnerability to be considered and proposes a new index that is independent of countries' political choices. Finally, Section 4 discusses how the principles can be implemented and the index used in a global allocation system for adaptation funds (Section 4).

2   Principles of allocation of climate change adaptation funds among developing countries: Specificity of adaptation

For climate change adaptation funds, as with development assistance, three principles of allocation must be combined: effectiveness of the use of the funds with regard to the objective, equity in their distribution between countries, and transparency. To allocate the funds in a multilateral framework, transparency can be sought through an allocation formula that expresses the consensus of stakeholders. This has been done by the multilateral development banks (MDB) with a 'performance-based allocation' (PBA) formula that leads to an allocation of the available resources on the basis of a predominant performance indicator[1] as well as income per head (with a lower level of this expressing greater needs for a country). The application of this formula has seen many changes, complications and exceptions, which have been criticised and greatly reduce the transparency of allocation (see, in particular, Kanbur 2005, Guillaumont and Wagner 2015, Guillaumont et al. 2015a). For the allocation of adaptation funds among developing countries, it is possible to use a different formula that ensures transparency while avoiding the criticism aimed at PBA.

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1   Derived mainly from the Country Policy and Institutional Assessment (CIPA), a composite index used by the MDBs.

2.1   Allocation for mitigation and allocation for adaptation: Two rationales

It is not possible to simultaneously determine the desirable geographical allocation of funds for adaptation and funds for mitigation, because their objectives are different.

Mitigation of climate change largely corresponds to the production of a global public good. It must be implemented in individual countries, but in the interest of the whole planet. Effectiveness is mainly assessed here in terms of avoided CO_2, rather than in terms of the development of the countries where mitigation is implemented. With regard to effectiveness, the corresponding funds should be used where mitigation opportunities are greatest (for a discussion, see the chapter by Massetti in this book). However, granted on a concessional basis to poor countries, these credits can also help the countries to implement a strategy of clean development, an example being funds for the maintenance of tropical forests (see also the chapter by Angelsen in this book). This criterion of needs can be satisfied by a simple condition of eligibility or by a modulation of concessionality according to income per head.

In contrast, adaptation concerns each country individually, and the funds a country receives for adaptation are supposed to be used for its own development. They can be channelled in different ways and according to specific criteria, but their use cannot be dissociated from that of development assistance. There is therefore a risk of fungibility undermining the additionality of resources. It is the specificity of the criteria applied to the allocation of adaptation funds that allows them to be differentiated from the other flows for development.

2.2   Adaptation: The ethical basis of a criterion of vulnerability to climate change

The specificity of vulnerability to climate change is obviously that most poor countries facing it are not responsible for it.[2] This vulnerability constitutes an allocation criterion for meeting the principle of equity (or need), which is without equivalent. There may be

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2   As noted by, among others, Kaudia in her chapter in this book that highlights the importance of adaptation for poor countries.

a precedent in the allocation of official development assistance (ODA), where structural economic vulnerability is sometimes considered as one of the possible allocation criteria. But for vulnerability to climate change the justification is stronger, for two reasons. First, and most importantly, there is a moral debt of the developed countries responsible for climate change owed to those who suffer from it. Birdsall and de Nevers (2012) speak of a 'causal responsibility', which creates an 'entitlement' for countries affected by climate change. Second, as will be seen below, it is possible to design a vulnerability index that is more clearly independent of countries' own choices than the index commonly used to measure structural economic vulnerability, namely, the UN's Economic Vulnerability Index (EVI).

Even if the idea of using an index of vulnerability to climate change as a criterion for the allocation of funds for adaptation was first presented in conjunction with the use of structural economic vulnerability as a criterion for the allocation of ODA (Guillaumont 2008, 2009 , 2015), it is independent of ODA because of its ethical basis. The idea was first proposed by Ferdi (Guillaumont and Simonet 2011, 2014) and by the Center for Global Development (CGD) (Wheeler 2011, Birdsall and De Nevers, 2012), as well as in works prepared for the World Bank's *World Development Report 2010* (Barr et al. 2010; Füssel, 2010, World Bank 2010), although these various works do not converge on the way to assess the vulnerability to be taken into account for allocation.[3]

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3   The few works since devoted to this topic seem to have been about the allocation of resources from the Green Climate Fund, dealing simultaneously with mitigation and adaptation (Polycarp et al. 2013), or dealing separately with adaptation (Noble 2013), but without using a quantitative criterion of vulnerability to climate change.

3 An index of vulnerability to climate change as a criterion for the allocation of the adaptation funds

3.1 What kind of indicator for measuring vulnerability?

There are many indices of vulnerability to climate (change?).[4] However, not being designed for this specific purpose, they generally do not meet the requirements for serving as a criterion for the allocation of adaptation resources.

First, the index must be independent of countries' policies. If a country's policy leads to a reduction of vulnerability by increasing the capacity for adaptation, i.e. resilience, this should not be a reason to reduce the allocation. Indeed, vulnerability includes two components which logically impact on the allocation but in opposite directions. Truly exogenous vulnerability, which results from a shock suffered by the country for which it is not responsible, unquestionably deserves external support. This is not the case for vulnerability that could be reduced by a country improving its ability to adapt. Good political resilience,[5] which lowers vulnerability, could be a possible performance criterion (if it is considered useful to have such a criterion). This distinction applies in particular to resilience that results both from structural factors – such as income per head or human capital, which are generally taken into account separately in the allocation process, with a low level resulting in more support – and resilience policy, weakness in which may lead to less support. Most of the available indices mix the two types of vulnerability, which of course enables them to offer a broad view of countries' vulnerabilities, but makes them inappropriate for allocation.[6]

Second, and for similar reasons, for international comparison and allocation it does not seem appropriate to use vulnerability indices corresponding to an assessment of the economic damage expected from climate change.[7] Considerable progress has been

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4   Survey in Fussel (2010), Guillaumont et al. (2015a) and Miola et al. (2015).

5   That can be translated into special measures such as external reserves, insurance mechanisms, and so on.

6   A significant example is given by the index ND-GAIN (University of Notre Dame Global Adaptation Index) (Chen et al. 2015).

7   Wheeler (2011) refers to the agricultural productivity losses estimated by Cline (2007) for the CGD.

made in the assessment of this damage, as evidenced in the review of the 'new climate economy' literature by Dell et al. (2014). The chapter by Hallegate et al. in this book provides examples. However, these estimates are inevitably open to debate and partial, as stressed by the authors. For example, agricultural production losses resulting from increased aridity in the distant future depend not only on the evolution of rainfall precipitation and temperatures, but also on the evolution of techniques, research, and agricultural policies. In addition, some economic damage from climate change is even more difficult to predict and measure (e.g. in the area of peace and security). Generally, damage estimates involve assumptions about adaptation policies that are specific to each country, and each country should make its own decision if the principles of ownership and alignment are to be met. Estimates of the costs of potential damage or adaptation carried out on a global scale are extremely useful for the global mobilisation of resources, but they cannot serve as the basis for the allocation of adaptation credits between countries.[8]

Third, the relevant vulnerability for the allocation of adaptation funds, because of the above-mentioned ethical argument, is vulnerability to climate *change*, not climate vulnerability in itself, which has always existed in various forms in different regions of the world. The latter 'climate' vulnerability does not entail the responsibility of developed countries in the same way.

In short, we propose the use of a *physical* index of vulnerability to climate change that is *exogenous*, implies no socioeconomic estimates, and captures in an adaptive way the impact of climate *change*, rather than just the climate itself. Since the index will reflect a change that is likely to continue, and the only non-debatable change is one that is observed (the prospects for which vary with the arrival of new observations), the index must be constantly updated.

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8   The World Bank highlights the fragility of the 'across country' conclusions on the costs of adaptation (World Bank 2010a, p. 89).

## 3.2   A Physical Vulnerability to Climate Change Index (PVCCI)

An indicator of vulnerability to climate change which meets the above-mentioned criteria (exogeneity of components, absence of socioeconomic variables, and a focus on the impact of the change) was set up by Ferdi in 2011 (Guillaumont and Simonet 2011) and subsequently revised on several occasions to use new data or to incorporate methodological improvements (Guillaumont and Simonet 2014; Guillaumont et al. 2015b). It is a dynamic, forward-looking indicator – although based on past data – that relies on a distinction between two kinds of risks that arise from climate change:

1. risks related to *progressive shocks*, such as the rise in sea level (risk of flooding), a rising trend for temperatures, or a decreasing trend in rainfall precipitation (risk of desertification); and

2. (2) risks associated with *the intensification of recurrent shocks*, whether rainfall shocks, temperature shocks, or cyclones.

For each of these two types of shock, the index – like the EVI – relies on a distinction between the size of shocks and the exposure to shocks. Since the sources of vulnerability are heterogeneous and the vulnerability of each country is specific, the indices corresponding to the various types of shocks are aggregated through a quadratic average, which gives more weight to those components that reflect vulnerability more.

In its current structure, the PVCCI does not include resilience (i.e. the capacity to adapt to shocks), since, as outlined above, resilience is determined by two categories of factors that influence the allocation in opposite directions: structural factors (income per head and human capital), and resilience policy.

Figure 1   Components of the Physical Vulnerability to Climate Change Index
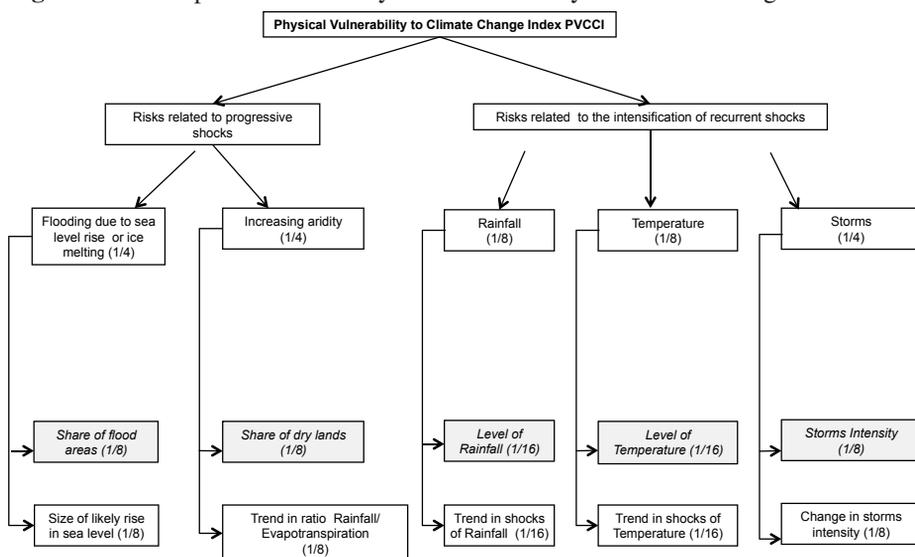
Note: The boxes correspond to the last rows of the graph respectively refer to exposure components (in italics) and to the size of the shocks component.

3.2   Groups of countries most vulnerable to climate change

The Addis Ababa declaration welcomes the objective of the Green Climate Fund to allocate half of its resources to 'vulnerable countries', identifying the LDCs, SIDS and African countries. For the consensus to operate, it should rely on a quantitative assessment. Estimates of the index may indeed differ according to the method of calculation. The latest Ferdi estimates[9] do not provide evidence of an average level of physical vulnerability to climate change for LDCs that is significantly different from that of other developing countries, but structural economic vulnerability among LDCs (using the EVI index) is significantly higher, which is to be expected as EVI is a criterion for the identification of least-developed countries. However, the PVCCI does not include structural resilience, which is much lower in LDCs (and Africa) due to lower levels of human capital and income per head. LDCs are therefore especially

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9   Calculations by Sosso Feindouno at Ferdi.

vulnerable to climate change if we consider 'structural vulnerability', including the physical vulnerability and the structural factors of low resilience.

For the SIDS, the average level of the PVCCI is slightly higher than that of other developing countries (and close to that of LDCs, which is not the case for EVI).

Table 1 Physical Vulnerability to Climate Change Index by country group

Group of countries	Average	Median	St. dev.	Min.	Max.
Developing countries (108)	45.6	44.7	7.3	31.4	63.2
LDC (47)	46.0	42.2	7.2	33.2	59.0
Non LDC (61)	45.2	45.8	7.5	31.4	63.2
SIDS (24)	47.8	48.2	9.1	31.4	63.2
SIDS-LDC (10)	47.5	48.1	9.1	33.2	59.0
SIDS Non-LDC (14)	48.0	48.2	9.4	31.4	63.2

There is in fact a large spread in the index scores within each country category, which is a major reason for determining the allocation country-by-country on the basis of criteria such as the PVCCI rather than by membership of a category. We can then examine the results for each category.

4   Implementation: Design and use of 'adaptation credits'

Now, assume that there is a consensus on an index of physical vulnerability to climate change, which is available to most developing countries. How can it be used for the allocation of adaptation funds? A consensus on an allocation formula is still needed which, from this index and other possible criteria, may determine an allocation of the total adaptation fund between countries. An 'adaptation credit' would correspond to the 'normal allocation' estimated for each country. On this basis, a country could apply to various financial institutions through which the adaptation funds would be channelled.

4.1   Measurement of the 'adaptation credits' from an allocation formula

The formula should express the simple idea that the adaptation funds must meet the needs of countries affected by climate change, for which they are not responsible

and which they are less able to cope with the poorer they are. The formula should be based on two essential criteria: physical vulnerability to climate change, and income per head (and/or the level of human capital). The variables corresponding to the two criteria would be introduced preferably in a multiplicative function, in order to show the elasticity of the allocation to each criterion.

The model may seem akin to the PBA that all the multilateral development banks use to allocate their concessional credits (Guillaumont and Wagner 2015). However, it is different for two reasons. First, it includes an indicator of vulnerability, while the MDBs so far have not integrated economic vulnerability in their model.[10] Second, and most importantly, in the PBA the criterion of 'performance' (essentially governance) plays a major role. Priority is given to effectiveness over equity. For the allocation of adaptation funds, the priority is instead on equity, because of the ethical basis for the financing of adaptation. It is essential that the adopted measure of vulnerability to climate change reflects a vulnerability *for which they are not responsible*, in order to justify the support of the international community. Income per head is utilised to reflect the need for concessional adaptation resources, with a low level indicating low structural resilience.

This approach is similar to the point of view expressed by Birdsall and de Nevers (2012), but it differs from the way in which some authors – influenced by the PBA and thus giving a major weight to the 'performance' measure – consider the allocation of funds for adaptation (Barr et al. 2010, World Bank 2010b). The model proposed here is a *vulnerability*-based allocation (VBA) rather than a PBA.

Using the same calibration of the variables as in the PBA model used by the MDBs and the same functional form, a model has been built from only three variables: level of income per head (AY), a measure of PVCCI (V), and the size of the population (P).[11] The results of a simulation carried out for illustrative purposes[12] on a sample of 106

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10 An exception is the Caribbean Development Bank. The European Commission has recently used EVI for the allocation of assistance (European Commission 2015).

11 According to the following formula, allocation to country $i = P^a i. AY^b i. V^c i$.

12 Simulations run by Laurent Wagner at Ferdi (here with the following parameters: a = 1; b = 2; c = 4). Simulations with a parameter a<1 are legitimate due to the structural resilience of small countries.

countries, using the latest version of Ferdi's PVCCI and figures for income per head and population from 2014, are given in Table 2. The table shows the following:

1. Column (1): The relative share of the allocation for LDCs, SIDS, low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs), and sub-Saharan African countries (SSA).

2. Column (2): The relative share of the population in each group.

3. Columns (3) and (4): An index of the relative allocation per capita, respectively a weighted average, given by the ratio of (1) to (2), and a simple average (index > 1 if the allocation per capita is higher than the global average), with some indicators of the spread within each group (in columns (5) to (7)).

According to this simulation, LDCs would receive over half of the adaptation credits. The SIDS group would receive a level of credits per head that is close to the average, due to the fact that many SIDS have a fairly high level of income per head. When an exponent lower than one is applied to the population size, in order to reflect a lower resilience due to small size, the allocation per head of the SIDS becomes higher than average. Of course, there is a wide range of scores for the index across countries.

Figure 2 summarises these observations by representing for each group of countries both the relative level of the allocation per head as a function of GNI per head, and the relative share of the total allocation (shown by the size of the bubbles).

It should be underlined that the 'normal allocations' are designated from continuous criteria and not from category membership. If LDCs receive half of the adaptation credits, this is due not to a quota but to their characteristics. Some LDCs may only be a slightly vulnerable to climate change and receive few credits for adaptation, while at the same time they may have a high economic vulnerability that is likely to lead to a relatively high level of ODA per head. Middle-income non-LDCs may be highly vulnerable to climate change, so justifying a fairly high level of allocation for adaptation, without being eligible for a high level of ODA. In this regard, the allocation of adaptation credits based on an indicator of vulnerability to climate change should help to achieve the 'smooth transition' wanted by the United Nations for the countries graduating from the LDC category, many of which are vulnerable to climate change.

Table 2 Vulnerability-based allocation of adaptation resources for 106 developing countries

	Share of allocated resources (%) (1)	Share of total population (%) (2)	Relative allocation per capita (weighted average) (3)=(1)/(2)	Relative allocation per capita (simple average) (4)	Relative allocation per capita (std. deviation) (5)	Relative allocation per capita (max.) (6)	Relative allocation per capita (min.) (7)
LIC	42.22%	20.03%	2.11	2.60	3.12	10.14	0.15
LMIC	48.37%	49.38%	0.98	1.15	1.40	4.99	0.01
UMIC	9.41%	30.59%	0.31	0.65	0.73	2.63	0.00
LDC	55.75%	30.28%	1.84	2.36	2.74	10.14	0.02
SIDS	1.71%	1.77%	0.97	1.06	1.07	3.75	0.01

Figure 2 Relative allocation per capita for adaptation and GNI per capita (a=1)
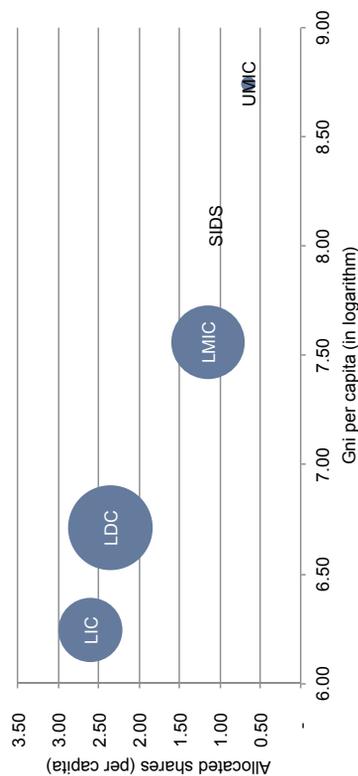
Under the influence of donors, governance factors might be introduced in the model of allocation of funds for adaptation, with a positive sign as a criterion of effectiveness or performance. A logical criterion would then be an indicator of resilience policy. But, as seen above, resilience related to a country's own willingness is difficult to measure. What could an alternative measure be? Could it be general economic performance through a measure similar to that used for the PBA? Or the quality of a country's policy to combat global warming, which is a more relevant criterion of allocation for mitigation than adaptation? Or an evaluation of the portfolio of projects implemented in the country using foreign aid?

None of these options seems legitimate with regard to the ethical argument specific to adaptation stated above. Should adaptation credits be reduced for a fragile state due to bad governance related to its fragility? When using credits, the quality of adaptation projects can be controlled.

4.2 Use of adaptation credits by countries: Competition between the accredited bodies

How could a country use its 'adaptation credit' ?

It seems to be agreed that a number of institutions will be accredited to receive additional climate resources from the international community (not only the Green Climate Fund, but also the MDBs, UNDP, and various bilateral development agencies). In the proposed system, a developing country to which an adaptation credit is allocated will be allowed to draw any part of this credit from the accredited institution of its choice. An international body (which may be the Green Climate Fund) will be responsible for keeping an account of the allocations received by the accredited institutions and the drawings made from them. The total amount of adaptation credits would not exceed that of the allocations. The allocations and the credits could be measured in terms of their grant element, so that projects can be implemented under the financial conditions that are most appropriate in each case.

Each country holding an adaptation credit may thus present to the institution of its choice projects or adaptation programmes. The accredited institution will ensure that it is a real adaptation project or programme, and will then analyse its modalities with

the country, as it does for its other operations. Each country can thus use its adaptation credit through the institution that offers the best financial conditions and technical services.

In the above, we have assumed that from the total resources mobilised for adaptation, what each accredited institution manages is determined on a discretionary basis by the adaptation fund donors. One might also imagine that the Green Climate Fund, instead of becoming an additional institution for direct funding of adaptation projects or programmes, could intervene simply as a refinancing body for the accredited institutions or as a subsidising instrument for eligible projects or programmes. Accredited institutions would then receive their resources partly and on a discretionary basis from bilateral sources, and partly (or only, if so decided by the international community) through the Green Climate Fund, depending on the quality of the programmes and projects that are submitted. Consistency with development programmes and projects would be achieved at the operational level by the accredited institutions, which are skilled in the art. Compliance with the objective of adaptation would be achieved through the mode of financing, in particular the Green Climate Fund, whose function for adaptation would then be redefined.

The use of funds described above for the adaptation process is legitimate only if donors are willing to ensure that mobilised funds are used to adapt, regardless of the risks of fungibility. The contribution of developed countries should be based on each country's responsibility for global warming. The proposal only aims at allocating the amount of additional resources that will be mobilised for adaptation by the international community. Donors can, of course, provide more adaptation resources than they will be committed to providing. They will be all the more inclined to do so since their development assistance, without being reduced, will be adapted to climate change.

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About the author

Patrick Guillaumont, Président of the Fondation pour les Etudes et Recherches sur le Développement International (Ferdi), is Emeritus Professor at the University of Auvergne and Director and Founder of the Revue d'économie du développement. He is also a member of the European Development Network (EUDN) and Fellow of the Oxford Center for Studies on African Economies (CSAE).