UNTT Working Group on Sustainable Development Financing

Chapter 1

Financing for sustainable development: Review of global investment requirement estimates

Contents

I – Introduction

At the UN Conference on Sustainable Development (Rio+20), Member States called for the prioritization of the sustainable development agenda and the effective allocation of resources for it in accordance with national priorities and needs, while launching efforts towards significant mobilization of resources from a variety of sources and the effective use of financing for sustainable development. An intergovernmental committee of experts has been tasked with "preparing a report proposing options for an effective sustainable development financing strategy to facilitate the mobilization of resources and their effective use in achieving sustainable development objectives." The mandate of the committee is to: (i) assess financing needs, (ii) consider the effectiveness, consistency and synergies of existing instruments and frameworks, and (iii) evaluate additional initiatives.

This background paper examines the first of these topics, i.e. assessing financing needs. Within this, the focus is on a review of investment needs based on recent estimates for a set of sectors and areas. Other important dimensions of financing needs, such as possible sources of financing and access to those sources, are addressed in companion papers produced by the working group.

Key issues relating to a discussion on financing needs for sustainable development are: Financing for what? Financing by whom? Financing through which mechanism? Given the specific scope of this paper, two dimensions are worth keeping in mind.

First, the scope of financing for sustainable development is broad. In line with the Johannesburg Plan of Implementation, sustainable development comprises three "overarching objectives and essential requirements": poverty eradication, changing consumption and production patterns, and managing the natural resource base for economic and social development (UN, 2002, paragraph 11). The first overarching objective as been re-emphasized at all UN conferences and summits since the Earth Summit in 1992, and most recently at the UN Conference on Sustainable Development (Rio+20). The third overarching objective encompasses the management of commons such as the atmosphere, biodiversity, oceans, and forests. Lastly, the second overarching objective, changing consumption and production patterns, reflects a recognition that outcomes in terms of poverty eradication and other economic, social and environmental issues are not independent, but are largely determined by the overall dynamics of the socio-economic system.

Second, a successful transition to sustainable development will require consistent and aligned actions and outcomes from a variety of actors. The large majority of resources invested in the economy are private investments or domestic public expenditures. The overall direction and speed of transformation will largely be determined by private investment processes, and by national resource allocation processes including public expenditures and the ability of those funds to induce private investments through a combination of policy and leverage. It is therefore critical that, to the extent possible, private sector activities are supportive of the agreed sustainability goals, norms and objectives.

In this context, the key role of global development policy in contributing to overall economic transformation may involve a combination of two broad sets of activities. On one hand, it would involve the elaboration and agreement on global rules (with supportive laws, regulations, norms and standards, including incentives) that align activities of and actions of all actors with sustainability objectives. On the other hand, strong commitment to reduce observed gaps is needed, for example in terms of poverty eradication, provision of public goods such as education, and maintenance and restoration of ecosystems and adopt targeted approaches to overcoming bottlenecks in areas or sectors that are considered critical to the functioning of the global economic system and to the achievement of global sustainable development objectives.

Within this framework, getting a clear picture of the financing needs for sustainable development in the future presents considerable conceptual and practical challenges. In order to quantify "needs," clear norms or normative targets have to be agreed upon. Different goals and targets and associated strategies to reach them entail different needs and as such would involve a range of financing requirement estimates. The choice of goals and targets for sustainable development pathways is currently being addressed through an intergovernmental UN process. Eventually once national governments adopt globally agreed sustainable development goals, they would be in a better position to assess their country needs. As such, evidence in this chapter should be read keeping these considerations in mind.

The paper is constructed as follows. Section 2 presents the main lessons drawn from the review of investment needs estimates. Section 3 reviews investment requirement estimates for the following sectors and thematic areas: Millennium Development Goals (MDGs); health; gender; infrastructure; agriculture, land management and rural development; energy; climate change mitigation and adaptation, other global commons (forests, biodiversity; oceans); and integrated sustainable development scenarios. The purpose is not to be exhaustive or to compare different estimates in full detail, but to provide a quick reference to existing figures. Section 4 briefly examines the needs of special groups of countries: Least Developing Countries (LDCs), Landlocked Developing Countries (LLDCs), and Small Island Developing States (SIDS). An overview of concepts relevant to this paper is presented in Annex 1. Annex 2 briefly surveys the methods currently used to estimate investment requirements in different sectors and areas, as well as caveats associated with each method and the interpretation of existing estimates.

II- Main lessons from a review of sectoral investment requirements

Getting a clear picture of the financing needs for sustainable development in the future presents considerable conceptual and practical challenges. First, as mentioned above, in order to quantify "*needs"*, clear norms or normative targets have to be agreed upon. Different goals and targets give rise to different needs. Importantly, different sustainability goals are associated with different time frames, and this has implications in terms of sequencing of investment and financing needs. Within each of the clusters considered here, the range of published estimates is wide, reflecting differences in scope, methodologies, baselines, and other factors. Studies that use normative targets as their basis for estimating investment needs rarely consider exactly the same sets of targets.

Second, it is critically important to distinguish costs from investment requirements. In many sectors as well as economy-wide, investment required for a transformation of the global economic system towards sustainable development may be high, whereas long-term (net) costs may be low or negative (net benefits). Costs and investment requirements can be defined only with respect to a counterfactual situation or baseline. A clear understanding of the baseline is critical to interpret the needs estimates.

Third, a transition to sustainable development would involve concerted action in a range of sectors. There are many interdependencies, synergies and trade-offs across sectors, which affects investment requirements and financing needs. In particular, there may be co-benefits or negative side effects among policies and actions taken in different sectors. Estimates from different sectors obtained in isolation generally cannot be added up due to double counting, inconsistency, and difficulty in accounting for cross-sector impacts. **To the extent possible, estimates of investment requirements or "needs" would have to be obtained from integrated models. However, the coverage of existing models is far from spanning the range of areas relevant for sustainable development**. Important dimensions are not well covered by existing estimates, including for urban development, peace and security and disaster risk management. In other clusters the existing picture is partial at best (for example, tourism, oceans).

Fourth, for sustainability purposes, the quality of investment (what technologies and services are invested in, for example, for energy infrastructure or agriculture) is as important as the amounts of investment. Yet, the extent to which the qualitative dimension is captured by existing models and studies is highly variable.

There is a further conceptual gap between "investment needs" and "financing needs". The latter incorporate the dimensions linked with the practical mobilization of finance for specific projects and programmes. Those are usually not examined in models that produce investment needs.

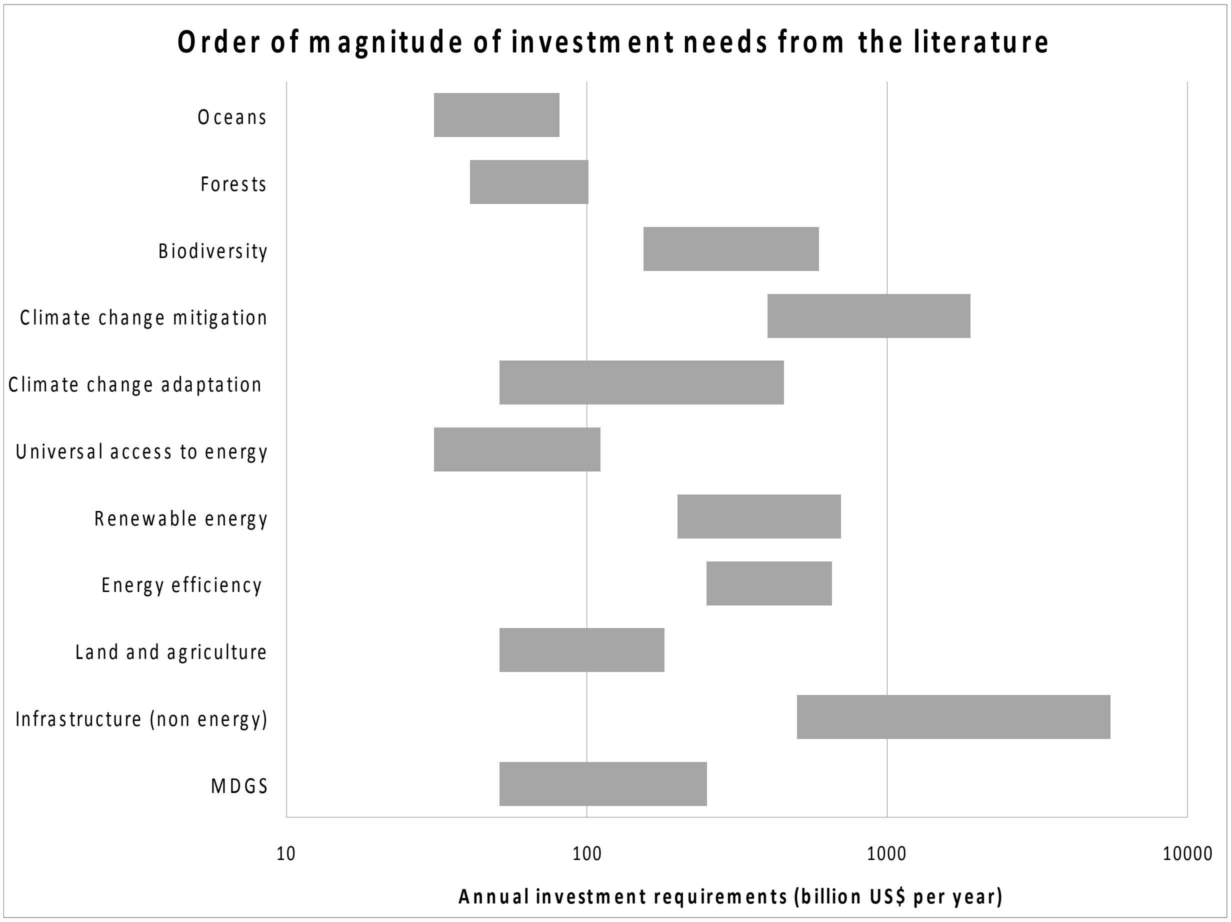
Lastly, depending on the context, barriers related to financing may not be the most critical obstacle to investment that is compatible with sustainability goals. National policy environments, both at the sector level and economy-wide, as well as international rules, norms and standards, may be as important to address. Yet this dimension is not factored in most quantitative models. The way international development aid is delivered can also importantly impact financing requirements. Efficient mechanisms for providing development assistance can reduce costs while producing positive outcomes faster and at a lower price tag. Alternatively, inefficient mechanisms for providing development assistance can vastly increase costs while delaying or deterring progress.

Bearing these caveats in mind, the paper reviewed published estimates of investment requirements for seven thematic areas or clusters: Millennium Development Goals (MDGs); infrastructure; agriculture, land management and rural development; energy; climate change mitigation and adaptation, other global commons (forests, biodiversity; oceans); and integrated sustainable development scenarios. Figure 1 illustrates the range of published estimates, as reviewed in this paper.

Investment requirements for infrastructure dominate the picture in terms of magnitude, whatever definition of infrastructure is used. Investment requirements for the energy transition respecting agreed climate targets are of the order of trillions US$ per year. Overall, investment requirements for "climate-compatible" and "sustainable development" scenarios (which include goals and target related to climate) are of the order of several trillions per year.

Investment requirements for MDGs and other related goals (e.g. universal access to electricity) are one order of magnitude lower than those related to climate change mitigation. The opportunity cost of achieving those goals would seem to be low, regardless of what other goals are adopted. The order of magnitude of estimated investment requirements for the management of global commons (biodiversity, oceans, forests) is several tens of billions per year.

Figure 1: Orders of magnitude of investment requirements for various sectors taken from the literature



Source: Authors' compilation.

Note: The x-axis is in logarithmic scale. The ranges of estimates shown in the figure are based on the figures presented in the text. Other estimates not reviewed here could be lower or higher. Due to the multiplicity of estimates, for some sectors or clusters, defining the range involves a dose of arbitrariness. Figures from different sectors and clusters should not be added up, as there are significant overlaps across them. Health and gender are not shown on this graph, as figures provided for this paper were on a per capita basis, instead of global annual investment amounts.

III- Investment requirements by sectors: Review of existing estimates

This section presents estimates of investment requirements for different clusters of sectors and areas. All the estimates come from published work. The full list of references is given at the end of this document. The purpose is to facilitate the comparison of estimates for financing requirements put forward by different institutions, that is, to put them in perspective with respect to scope, methodology used and underlying assumptions.while highlighting the key limitations faced by those estimates.

Unless stated otherwise, the numerical estimates provided in this paper focus on investment requirements (where investment is understood in a broad sense), as the most relevant concept from the perspective of investment and financing, which is the focus of this paper. The paper does not review estimates of damages or benefit from undertaking or failing to undertake specific actions (for example, regarding biodiversity and ecosystem conservation, or managing fisheries sustainably). More qualitative dimensions of financing needs, which are of primary importance for the issue of financing for sustainable development, are considered in detail in the other background papers produced by the working group.

The choice of clusters of sectors and areas covered in this paper was made based on data availability. Historically, the production of estimates has tended to follow political processes. This explains why, for example, many attempts have been made to cost the MDGs. The perimeters of these costing exercises can overlap (for example, the Aichi targets include goals that are related to forests and oceans, see below section III.8.1; climate change adaptation covers a wide range of sectors). For other sectors or clusters, especially those for which no high-visibility internationally agreed goals or targets exist, estimates are more difficult to find. The coverage of areas is also determined by the input received from the contributors to this working paper. We considered the following clusters/ areas:[1]

- MDGs;
- Health;
- Gender;
- Infrastructure;
- Agriculture, land management and rural development;
- Energy;
- Climate change;
- Other global commons (forests, biodiversity; oceans);
- Integrated sustainable development scenarios.

In each area/cluster, we only cover a subset of existing estimates.

An important cluster that is not covered in this paper is peace and security. This area was recognized as a fundamental prerequisite for sustainable development at the Earth Summit in 1992 (cf. Rio Principles 23, 24 and 25). It has been recognized as a critical dimension of sustainable development in the Millennium Declaration and at the 2005 World Summit, as well as in the UN paper "Realizing the Future We Want", produced in the context of the post-2015 development agenda (UN, 2012). Unfortunately, estimates of long-term investment requirements in this area do not seem to be readily available. Disaster risk management is also an area where global estimates are not readily available, in spite of its importance for many countries including SIDS. To some degree, investments in disaster risk management and resilience intersect with thematic areas and may be partially reflected in existing estimates (e.g. for climate change adaptation), but a better picture would clearly be needed.

III.1. MDGs

Since their adoption, several institutions and authors have estimated the financial needs to meet the MDGs by 2015 at the global level. There is high heterogeneity among methodologies used, scope of the analyses and related results.

Most studies focus on investment costs, with few considering net economic costs, one such example being Markandya et al. (2010). Researchers have mostly used growth models, unit cost analyses and back of the envelope calculations to estimate the necessary additional resources. For example, the UN Millennium Project (2005) analyzed necessary policies and interventions for all MDGs at the country

[1] In particular, this paper does not cover in detail sectors that are reflected in the MDGs, such as education, water and sanitation, slum upgrading, etc. The paper does not engage in a discussion of the relative relevance (as perceived by individual countries) of the needs for which estimates are reviewed here.

level for five countries and then extrapolated to reach a global estimate for the additional ODA needs to meet the Goals.

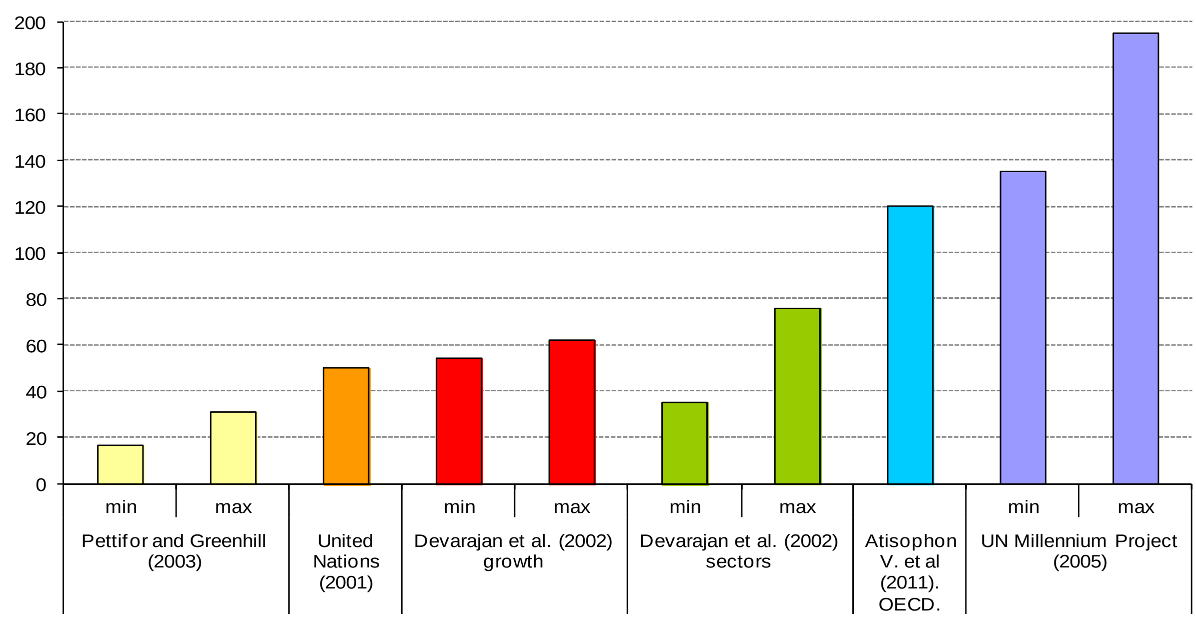
The scope of the majority of the estimates includes goals for poverty eradication, education and health. Gender dimensions are primary captured in the education calculations, as in Devarajan et al. (2002) and in Atisophon et al. (2011). MDG 7 is usually absent from global estimates, except for the targets related to access to drinking water and improving lives of 100 million slum dwellers, as in, for example, Pettifor and Greenhill (2003).

The majority of the studies do not factor the impact cost of capacity and institution building (for example through technical cooperation) or for reforming the policy environment, as well and administrative and transaction costs. One exception is the UN Millennium Project (2005), which includes estimates at the global level for capacity building, regional cooperation and infrastructure and financing the implementation of the Rio conventions, among others.

MDGs researchers seem to increasingly agree on the need for higher quality and detailed assessments at the country level, compared to separate sector estimates at the global level. Country estimates are underpinned by a more complete analysis of national conditions and allow for possible synergies in the achievement of the different goals at the national level. Computable general equilibrium models have become popular in this context for their ability to incorporate synergies and cross-sectoral impacts, as well as different scenarios for resource mobilization, as in Bourguignon, Diaz-Bonilla and Lofgren (2008), Vos, Sánchez and Kaldewei (2010) and Sánchez, Vos, Inoue and Kabulova (2013).

Global estimates mostly aim at giving a sense of the magnitude of the funds that will be required from the international community in order to achieve internationally agreed development goals. The range of published global estimates presented has varied from $20 billion to $200 billion annually. A selection of estimates is presented in Figure 2.

Figure 2: Additional financing needs to reach the MDGs
(In USD billion per year)



Source: Authors' elaboration.

III.2. Health

Health is a fundamental pillar of human development that features prominently in the Human Development Index, alongside education and poverty. Health has been a central focus of the United Nations for many decades before the Millennium Declaration, with early milestones including the Declaration of Alma-Ata (WHO, 1978) and the Health For All Campaign. In the MDG Declaration, Health comprised three of the eight (specifically, MDG 4 (reducing child mortality), MDG5 (improving maternal health) and MDG6 (combating HIV/AIDS, malaria and other diseases)) and was tightly linked to the other five MDGs.

Critical for the results on health indicators, as identified by the WHO Six Pillars (WHO, 2007) are: the sector Governance & Stewardship (that involve developing sector strategies to clarify roles and manage competing demands), Financing (to ensure adequate, fair and sustainable financing, including financial risk protection), Human resource management (to ensure adequate availability and productivity of health workers and other key resources), Pharmaceutical & Supplies management (to ensure access to essential drugs, equipment and infrastructure), Service Delivery (to improve organization, management and quality of Services & information), and Health Information & Knowledge Systems (to ensure a well-functioning system to generate, process, analyze and use population- and facility-based data). In addition to those elements, the Ouagadougou Declaration (WHO, 2008) added Community Ownership & Participation, Partnership for Health Development and Research for Health as other critical areas of the health system.

Resource estimates for health needs are often presented in three categories: direct service costs, health systems costs and health programmes costs. Direct service costs refer to the costs incurred in providing the heath service itself, such as the drugs and supplies used in caring for a patient. Health systems costs include many, if not all, of the elements presented above. Lastly, health programme costs reflect the elements required to enable a health programme to succeed above and beyond the components already reflected in the health system, including staff supporting the programmes, programme-specific training, supervision, monitoring and evaluation, infrastructure and equipment, transport, media and communications, and general programme-management activities. In the analysis as well as the reporting the results, attention is usually paid to the distinction between capital versus recurrent costs, as they have different implications for fund raising and sustainability of the health system.

Resource estimates are usually derived at a national level, where measures of the baseline epidemiology and coverage are used with simple assumptions applied for the unit costs, coverage targets and scale-up patterns, as well as key health systems assumptions. Such national estimates are then aggregated to produce regional and global "price tags" that allow to estimate the resources required to scale up a set of interventions in line with MDG targets and indicators. Causes of morbidity and mortality are often mapped to specific health interventions which have been effective in averting the stress. Such mapping enables researchers to estimate the expected overall impact of scaling up intervention and services on health outcomes such as deaths averted.

Numerous efforts have been undertaken to estimate the costs of providing basic health services in developing countries. Results are influenced by the scope of the studies in terms of the set of countries used in the analysis, the set of interventions and elements of the health system that are considered, as well as assumptions concerning unit costs, projected coverage, and economies (or diseconomies) of scale. A number of multi-country and global price tags have been developed since 2000, with somewhat different scopes in terms of countries and interventions covered and all with target coverage rates aimed between 80% and 100%. Despite this variation, they tend to estimate reasonably consistent orders of magnitude for the cost of a basic package of health services. Initial analysis following the MDG Declaration stated that essential interventions could be covered at a price of $34 per person per year (Commission on Macroeconomics and Health, 2001). Other early estimates projected incremental country-specific annual financial needs per capita ranged between US $0.53 to $8.75 (Kumaranayake et al., 2001), while 2007 WHO estimates for child health only were generally less than $3 per capita per year (Stenberg et al., 2007).

More recent estimates such as the 2009 High Level Task Force on Innovative Financing took a more comprehensive approach, with greater attention to the necessary health system components, a more complete set of health interventions as well as projections of impact. This global price tag pointed to an incremental annual cost per capita of nearly $25 from 2009 to 2015 (WHO, 2010). This set of estimates were projected to avert 23 million deaths from 2009–2015. It projected significant progress being made in the expansion of access to health services for HIV/AIDS and tuberculosis while achieving the targets to reduce malaria mortality.

A key item that is repeatedly identified in these types of resource estimates is the often higher return on investment for preventative versus treatment. In HIV/AIDS, it is well established that the costs of preventing new infections is substantially lower than the treatment costs. In the areas of sexual and reproductive health, meeting the unmet need for family planning produces a cost savings to the health care system compared to scenarios where there is less prevention of unintended pregnancies (Singh et al., 2009).

III.3. Gender

It is rare to find tools that estimate a full set of comprehensive costs for interventions to promote gender equality and empower women. Rather, most tools and studies that estimate the financing requirements for gender equality only estimate the costs in sectors like health or education.[2]

Research by Grown et al. (2008) goes beyond such a single sector approach and applies a systematic analytical framework to identify the costs of MDGs that relate to gender equality. They distinguish three categories of interventions: (i) "core" MDG3-related interventions (e.g. guarantee sexual and reproductive health and rights; combat violence against women); (ii) interventions implemented in other sectors covered by the MDGs that aim at gender mainstreaming ("gender mainstreaming interventions", for example maternal health or scholarships for girls); and (iii) other interventions that, although not directly aimed at improving gender equality, have beneficial impacts in that respect (for example, providing access to drinking water). Costs of achieving gender equality are computed as the sum of costs of interventions in the first two categories plus a portion of the costs of those in the third category. The list of interventions considered is drawn from the list developed by the UN Millennium Project (2005).

Using this method, the average annual per capita costs of improving gender equality and women's empowerment in five low-income countries (Bangladesh, Cambodia, Ghana, Tanzania, and Uganda) was found to be ranging between $37 - $57, which represent between 35-49 percent of the total costs of achieving the Millennium Development Goals in these countries (Grown et al., 2008). While the latter figures may seem high, one has to note that 69-77 percent of the costs come from "non-targeted" activities across virtually every MDG sector, such as improving water supply and sanitation services,

[2] The main instrument that articulates a State's obligations to meeting gender equality commitments is the national action plan for gender equality. While national development strategies and sector plans might have specific gender-related components or targets, it is the national action plan for gender equality that outlines existing gender disparities and the steps to be taken to address these gaps. Costing of the gender action plan is therefore an important prerequisite for meeting state obligations on gender equality and women empowerment.

upgrading childcare centers, building roads, subsidizing home energy costs, and improving infant and child health and survival. A far smaller share of the cost relates to "direct" gender equality-promoting activities related to specific MDG 3 targets – such as eliminating school fees for girls and user fees for poor women, building the capacity of women's machineries/ministries for gender equality and supporting women in the political process. In other words, the major part of the cost comes from MDG programmes that advance gender equality implemented through sectoral initiatives in agriculture, infrastructure, employment, education, health, and so on – highlighting the cross-cutting dimension of gender. Due to this, costs of gender equality estimated in this way cannot be directly added to other sectoral costs for other development objectives, as by construction this would involve double counting.

III.4. Infrastructure

Estimates of investment requirements widely vary in coverage and scope. Some studies focus on core infrastructure such as roads, bridges, and port infrastructure and to varying extents energy production and transmission infrastructure. The inclusion or exculusion of buildings in the definition of infrastructure results in estimates typically ranging from 1 to 2 or more. In addition, lack of data on infrastructure spending has been long recognized as a serious impediment to deriving reliable needs and gaps estimates (Fay, 2010).

A World Bank paper (Yepes, 2008, quoted in Estache, 2010) estimated developing country needs at US$1.1 trillion per year, 40% of which would be allocated to new investments and 60% for operation and maintenance. Fay et al. (2010, pp. 365-366) provides a "guesstimate" of US$ 1,250-1,500 billion per year for developing countries for total investment requirements, out of which incremental investment requirements are about US$600-700 billion. In addition to that, US$140-177 billion would be needed for climate mitigation and US$75-100 billion for adaptation, in order to make infrastructure more sustainable. In early 2013, on request of G20 the World Bank/UN and other international organization estimated annual investment needs for infrastructure to be around US$ 1 trillion in developing countries through 2020, with additional $200-300 billion per year required to "ensure that infrastructure investments are low emitting and climate resilient" (World Bank, 2013). A recent G24 policy paper retains the estimate of US$ 1 trillion additional spending needed in developing countries (Battacharya et al., 2012). Lastly, a McKinsey report from 2013 put global infrastructure investment needs for 2013-2030 at US$ 57 trillion, or about US 3.2 trillion annually on average (McKinsey, 2013). Estimates published by Kennedy and Corfee-Morlot (2013), based on OECD work, are in the high part of the range, with annual investment requirements estimated at US$ 6.6-7.2 billion including buildings and vehicles, and US$ 2.7-3.2 billion when those are excluded.

Figure 3: Investment in infrastructure: current investments and estimated needs

Source: Fay et al. (2010).

Estimates of investment requirements for infrastructure at the regional level have been undertaken by the World Bank, using different methodologies. For example, in 2005 the World Bank estimates of new annual infrastructure investment needs in the South Asia Region were US$88 billion (World Bank, 2005). This estimate was based on the level of investment required to reach an annual growth rate of 7.5% for the region. According to a 2010 study (AFD and World Bank, 2010), the financial requirement of addressing Africa's infrastructure needs was around US$93 billion per year, in order to reach normative goals, such as doubling Africa's irrigated area, meeting the MDGs for water and sanitation, and raising the household electrification rates by 10 percentage points. In a study published two years earlier and involving the same authors, the World Bank had estimated the annual investment needs in the same set of sectors to US$76 billion (World Bank, 2008). Other development banks have also estimated regional needs. The Asian Development Bank (ADB), based on Battacharyay (2010), put forward estimates of infrastructure investment needs for the whole Asia and Pacific region of about US$800 billion a year from 2010 to 2020. [3]

A recent global assessment of transport infrastructure investments by IEA (2013) has estimated capital investment and operation and maintenance costs at the global level to 2050, with a breakdown between OECD and non-OECD countries. The analysis is based on the IEA Mobility Model (MoMo). It is a global transport model that provides historical data and projections to 2050 for the transport sector detailed by transport mode, fuel and region, including energy and GEG implications. The IEA study provides results for two climate-related scenarios: 4 degree Celsius (reference scenario) and a 2 degree Celsius scenario. According to that study, expenditures on transport infrastructure (including new roads,

[3] This includes both national infrastructure needs and needs for cooperative cross-border infrastructure projects.

upgrade of existing roads, Bus Rapid Transit, high-speed rail, and parking space) would be average **US$ 2.5-3 trillion** annually to 2050, with requirements increasing over time (US$ 1.1-1.3 billion for OECD countries and US$ 1.3-1.6 billion for non-OECD countries). Compared with the 4^{o}C scenario, the 2^{o}C scenario would translate into average savings of US$ 500 billion annually over the period (IEA, 2013). Kennedy and Corfee-Morlot (2013) put the incremental cost of a low carbon scenario in the range of US$ −70 to 450 billion when buildings and vehicles are included, and US$ −440 to 80 billion when they are excluded.

III.5. Agriculture, land management and rural development

There is broad agreement that more investment in agriculture is needed. The issue of agricultural transformation, and particularly the sustainable intensification of smallholder agriculture in low and middle income countries, relates to many other development issues (for example, food security, poverty and social inclusion, rural-urban linkages, trade, water and energy use, natural cycles) and to the provision of global public goods. This cluster therefore represents a challenge when it comes to estimating investment and financing requirements. In particular, given these numerous linkages, focusing on narrow goals and targets as is done other clusters may be inadequate.

As a consequence, satisfactory estimates of the financing requirements for an agricultural transformation that would be compatible with sustainability are difficult to find. Assumptions made regarding both private and public investment are often unclear. In general, there are problems arising from the fact that public and private investments are not mutually independent.[4]

Investment requirements have been estimated both based on normative targets and based on econometric relationships between macro-economic variables. An estimate of the former category done by FAO and focusing on needs to support investment in rural infrastructure, natural resource conservation, research, development and extension, rural institutions and to provide safety nets aimed at those suffering from hunger arrives at US$50.2 billion annually in addition to existing levels of spending.

The PBL report to the Club of Rome focused on investments needed to increase agricultural yields worldwide up to a level that will provide all of humanity with basic food supply without a further expansion of agricultural land areas. The conclusion from the report is that this would require "probably less than 50 billion USD per year" (PBL, 2009). From the report, it is unclear how this number was derived.

Using econometric methods, another set of reports (Schmidhuber et al 2009, FAO 2009) estimated in developing countries, the establishment of a balance between (increasingly urban) demand (as powered by demographic and income change) and supply for agricultural products would require private investment of US$9.2 trillion over the 2005/7-2050 period. This would involve an average net annual investment (i.e., beyond capital stock replacement) of US$83 billion. In addition, it is estimated that reaching social goals of freedom from hunger, lowering vulnerability and enhancing resilience would require an additional public expenditure of US$750 billion over the 2010-2025 period. The econometric assumptions and theories of change underlying these estimates are unclear. It should be noted that these cost estimates specifically exclude necessary public and private investments for resource-use sustainability and climate change adaption and mitigation.

[4] In addition, the paucity of existing data on current investment in agriculture is also an important constraint.

III.6. Energy

The energy sector has been one of the most closely studied by modelers because of its close relationship with climate change mitigation. Therefore there is a growing number of estimates of the level of investment required to transform energy access, efficiency and low-carbon energy, in accordance with target levels for GHG concentrations. Many are added every year, including in the context of IPCC reports. In addition, estimates of investment requirements for the three goals included in the Sustainable Energy for All initiative of the UN Secretary-General have also featured prominently in recent publications.

The Global Energy Assessment (GEA) released in 2012 has produced one of the most comprehensive sets of scenarios and related investment requirements in the energy sector. Table 1 below summarizes some of the main goals and targets considered in the GEA, the suggested policies in order to achieve those targets, and the related estimates of investment requirements.

Investment requirements for energy systems vary according to the ambition of the long-term targets that are chosen for the climate. The reference for the scenarios has tended to become the 2 degrees target, as it has been officially adopted by political forums.

For *energy access*, the IEA estimates that USD 49 billion per year will be required up to 2030 to provide universal access to modern energy services (45 billion for universal electricity access and 4.4 billion for clean cooking). This represents a five-fold increase from the observed level of investment in 2009 (IEA 2011b). In 2006, the World Bank estimated the cost of universal access to electricity US$ 34 billion/year (World Bank 2006).

To meet the UN 2030 goal on *energy efficiency* would require from US$ 250-400 billion per year in additional investment.

For *renewables*, the IEA in its baseline scenario estimates that power sector investments of USD 500 billion on average are needed annually. Additionally, around USD 150 billion per year is needed in the IEA 450 ppm scenario. This excludes buildings, industry and transport (IEA 2011b).

Finally, the World Bank (2006) estimated that the annual investment for the power sector in developing countries would need to rise from US$160 to US$190 billion over the period 2010–2030, assuming stabilization at 450 ppm. The incremental investment of US$30 billion per year appears low compared with the needs estimated in climate mitigation scenarios for energy systems (see below).

Focusing on renewable energy only, total investment requirements estimates are reviewed in the recent IPCC special report on renewable energy (Fideschik et al., 2010): The report illustrates the variety of estimates by considering four scenarios, the first of which being a baseline scenario under which no significant change in policy happens. The estimated cumulative global investment in different renewable energy technologies range from US$ 136 (149) billion per year under the baseline scenario to US$ 510 (718) billion per year for the decade 2011-2020 (2021-2030) under a scenario which seeks to stabilize atmospheric CO_2 concentrations at 450 ppm. Estimated investment requirements increase to over a trillion US$ per year under two scenarios adopting (mildly) stringent climate targets. The numbers for the periods 2011-2020 and 2021-2030 would correspond to a three-fold (five-fold) increase in global investments in renewable energy, compared to a baseline scenario (Fideschik et al., 2010).

Table 1. Summary of model inputs, outputs and ex-post interpretations of IIASA's GEA scenarios

Goals	Targets	By	Pathway characteristics	Investments
Improve energy access	Universal access to electricity and modern cooking fuels	2030	Diffusion of clean and efficient cooking appliances. Extension of high voltage electricity grids and decentralized micro-grids. Increased financial assistance from industrialzied countries to support clean energy infrastructure.	Estimated investment to connect 1.6 billion people with lowest income: US$55-130 billion per year to 2030. Estimated investment to provide rural grid connections: >US$11 billion per year to 2030.
Improve energy security	Limit energy trade, increase diversity and resilience of energy supply	2050	Increase in local energy supply options (e.g., renewables to provide 40-70% of primary energy by 2050). Increase in diversity of imported fuels and reduce dependency (e.g., reduce share of oil in imports in primary energy by 30-80% by 2050 compared to 2000). Infrastructure expansion and upgrades to support interconnections and back-up, including increased capacity reserves and stockpiles.	Estimated investment in infrastructure upgrades for the electricity grid: >300 billion per year by 2050. Co-benefits of stringent climate mitigation policies reduce overall security costs (import dependency & diversity) by about 75%.
Reduce air pollution and improve human health	Reduce premature deaths due to air pollution by 50%	2030	Tightening of technology standards across transportation and industrial sectors (e.g., vehicles, shipping, power generation, industrial processes). Combined emissions pricing and quantity caps (with trading). Fuel switching from traditional biomass to modern energy forms for cooking in developing countries.	Estimated investment to meet air pollution targets: US$200 billion per year to 2030 (~12% of energy costs). Co-benefits of stringent climate mitigation policies reduce overall pollution control costs by about 75%.
Avoid dangerous climate change	Limit global average temperature change to 2C above pre-industrial levels with a likelihood of >50%.	2050, 2100	Widespread diffusion of zero and low-carbon energy supply technologies, with substantial reductions in energy intensity. Global CO_2 emissions peak by 2020 and are reduced to 35-75% by 2050 on 2000 levels. Globally comprehensive mitigation efforts covering all major emitters. Financial transfers from industrial countries to support decarbonisation.	Up-scaling of investments into low-carbon technologies and efficiency measures > US$465 billion per year to 2050. Additional financial transfers to developing countries of about 2-5% of total energy system costs to 2050, depending on the domestic commitment of industrialized countries.

Source: Roehrl (2012), adapted from Riahi et al. (2012).

As with other sectors or clusters, estimates from different sub-sectors or based on different targets cannot be simply added up, as there are strong interdependences among them. For example, the GEA (2012) examines the cost of measures to reduce premature deaths due to air pollution by 50% in 2030.[5] The estimated investment to meet air pollution targets is US$200 billion per year to 2030. However, co-benefits of stringent climate mitigation policies reduce overall pollution control costs by about 75%.

[5] Those include the tightening of technology standards across transportation and industrial sectors, combined emissions pricing and quantity caps (with trading), and fuel switching from traditional biomass to modern energy forms for cooking in developing countries (Roehrl, 2012).

III.7. Climate change

Estimates of investment requirement for climate change are usually computed separately for mitigation and adaptation._Studies that estimate the incremental investment and/or costs of mitigation identify four categories of measures:
1. Energy efficiency measures (buildings, industry and transportation);
2. Low-carbon energy supply (biofuels and renewables, nuclear) and carbon capture and storage (CCS) for electricity supply;
3. Reduction of other GHG emissions, including CCS for industrial emissions;
4. Carbon sinks (agriculture and forestry).

Many of the studies focus on the first two categories. A recent study (Olbrisch et al., 2011) has compared estimates of global incremental investment requirements for mitigation from three often quoted studies (UNFCCC, 2007; McKinsey & Co., 2009a; IEA, 2009). The study includes a breakdown of investment requirements for developing countries. These estimates are reproduced below in Table 2.

Table 2: Summary of global incremental mitigation investment estimates for 2030 (billions of US$ per year)

	Global			Developing countries		
	UNFCCC[a]	McKinsey[a]	IEA[a]	UNFCCC[a]	McKinsey[a]	IEA[a]
Fossil-fuel supply	–59[b]	27	–128	–32[b]		
Electricity supply	148[c]	222	142[d]	73[c]		72[d]
Biofuels			38			9
Buildings	51	297	206	14		87
Industry	36	142	88	19		57
Transportation	88	450	334	36		152
Agriculture	35	0		13		
Forestry	21	65		21		
Other	1	12		1		
Total	380[e]	1215	808[e]	177[e]	695	377

Notes: [a]In 2030 for UNFCCC; annual average for 2026–2030 for McKinsey; annual average for 2021–2030 for IEA. 2005 US$ for UNFCCC; 2008 US$ for IEA; McKinsey estimates reported in euros converted to US$ at the rate of €1 = US$1.50.
[b]Global (developing country) investment for fossil-fuel supply in 2030 drops from US$322 (156) to US$263 (124) billion.
[c]Global (developing country) investment in fossil-fired generation and transmission falls by US$156 (79) billion while investment in renewables, nuclear and CCS rises by US$148 (73) billion.
[d]Power generation only: transmission and distribution are not included.
[e]Excludes reduced investment in fossil-fuel supply.
Sources: UNFCCC (2007), IEA (2009) and McKinsey & Co. (2009a).

Source: Olbrisch et al., 2011.

The scope of the three studies is different. UNFCCC and McKinsey estimates cover all mitigation options, whereas the IEA figures are for mitigation of energy-related CO_2 emissions. The UNFCCC includes annual costs for measures, such as reduced forest degradation, that do not require incremental investment. The targets considered also vary.

The UNFCCC study combined several estimates of the mitigation potential for different categories of emissions to reduce projected emissions in 2030 20% below 1990 emissions (UNFCCC, 2007, 2008). The additional investment and financial flows in 2030 were estimated at US$ 380 billion, of which US$ 177 billion (47%) would be needed in developing countries.

McKinsey developed a GHG abatement cost curve which includes mitigation measures covering 10 sectors in 21 regions with each measure reducing emissions at a cost less than US$90/t$CO_2$e (McKinsey & Co., 2009a). Implementing all of the measures to their full potential could reduce projected emissions in 2030 to 10% below 1990 emissions. McKinsey estimates that the incremental investment needed to implement these mitigation measures would be US$ 1,215 billion per year during the period 2026–2030, of which US$ 695 billion (57%) would be in developing countries (McKinsey & Co., 2009a).

Focusing on a 450 ppm scenario where emissions in 2030 are approximately equal to 1990 emissions, the IEA arrives at an average annual incremental investment for 2021–2030 of US$ 808 billion globally, of which US$377 billion (47%) in developing countries.[6]

The World Bank (2010a) has compiled several estimates of the incremental costs and financing requirements for the mitigation efforts needed in developing countries in 2030 to ultimately stabilize atmospheric concentrations of CO_2e at 450 parts per million (ppm). These are presented in Table 3, together with the estimates reported in Table 2. The McKinsey and UNFCCC estimates include all sectors; the other figures only include mitigation efforts in the energy sector.

Table 3: Estimates of incremental mitigation investment/costs for developing countries in 2030 (2005 US$ billions per year)

Study/model	Incremental investment	Incremental cost
IEA Energy Technology Perspectives[a]	565[a]	
IEA World Energy Outlook 2009[b]	377[b]	
McKinsey[c]	563[c]	175[c]
MESSAGE	264	
MiniCAM[d]		139[d]
REMIND	384	
UNFCCC 2007[b]	177[b]	

Notes: [a]Annual average up to 2050 (IEA, 2008).
[b]See notes to Table 1.
[c]Using a dollar-to-euro exchange rate of US$1.25 to €1. The McKinsey figure in Table 1 reflects an exchange rate of US$1.50 to €1. After adjusting for the different exchange rate, the figures are essentially the same.
[d]MiniCAM reports US$168 billion in mitigation costs in 2035, in constant 2000 dollars; this figure has been interpolated to 2030 and converted to 2005 dollars.
Sources: UNFCCC (2007), IEA (2009) and World Bank (2010a).

Source: Olbrisch et al., 2011.

Compared to climate mitigation, estimates of costs and investment requirements for climate change adaptation are more scarce, and tend to be less involved and more ad hoc in terms of their methodology. The most quoted study on adaptation costs is the one done by UNFCCC in 2007. The study included agriculture, water, human health, coastal zones, and infrastructure. Estimates were generally derived by applying “climate mark-ups” to investment requirement estimates in the different sectors. For example, UNFCCC estimated the annual cost of adaptation in agriculture at $11.3–12.6 billion by 2030. The basis for this is an assumption that the ‘climate mark-up’ will amount to 10% of research and extension expenditure, and 2% of agricultural infrastructure expenditure. Within sectors, only specific goals or sub-sectors are considered. For example, for water, the UNFCCC costs include those related to drinking water provision, but not those related to adapting to altered flood risk in river basins. On this

[6] This figure does not reflect the reduced investment for fossil-fuel supply of approximately US$135 billion per year globally, nor the reduced investment for transmission and distribution, which is not reported but could be of the order of US$90–100 billion per year.

basis, the UNFCCC estimates have been criticized as being too low. A study by IIED concluded that ***"…the UNFCCC estimate of investment needs is probably an under-estimate by a factor of between 2 and 3 for the included sectors. It could be much more if other sectors are considered."*** (Parry et al., 2009).

A recent project run by the World Bank, Economics of Adaptation to Climate Change, developed a global estimate of adaptation costs. The study used both top-down and bottom-up (country-level) estimates from seven countries. The synthesis study report finds that the cost between 2010 and 2050 of adapting to an approximately 2°C warmer world by 2050 is in the range of \$70 billion to \$100 billion a year. The study provides a regional breakdown of estimates for two climate scenarios (World Bank, 2010).

Table 4: UNFCCC, World Bank and IIED estimates of annual investment needs by 2030 to cover costs of adaptation to climate change (billion US dollars per year in present day values)

	UNFCCC (2007)			IIED (2009)	World Bank (2010)
	Global cost	Developed countries	Developing countries	Factor of underestimation or alternative estimate	Total costs, developing countries only
Sectors included in UNFCCC study					
Agriculture	14	7	7	n.a.	2.5 – 3 (including forests and fisheries)
Water	11	2	9	Underestimation because flood control is not included	14.4 – 19.7
Human health	5	Not estimated	5	More than 2	1.5 – 2
Coastal zones	11	7	4	2 to 3	27.6 – 28.5
Infrastructure	8–130	6–88	2–41	"Several times"	13 – 27.5
Sectors not included in UNFCCC study and mentioned by IIED (2009) or World Bank (2010)					
Ecosystem protection				65-300	No estimate provided by WB
Mining and manufacturing, energy, retail and financial sectors, tourism				No estimate provided by IIED	No estimate provided by WB
Extreme weather events				No estimate provided by IIED	6.4 – 6.7
Total	**49–171**	**22–105**	**27–66**	**n.a.**	**71 - 81**

Source: Authors' compilation from UNFCCC (2007), IIED (2009), World Bank (2010).

III.8. Global commons, except climate

Global commons considered here include biodiversity, forests, oceans (in addition to climate which been reviewed above). There are important interdependences and common drivers among these three clusters. In addition, climate change impacts all of them. For this reason, estimates of investments needs in each of the clusters are both difficult to obtain in isolation, and impossible to add up without detailed examination because of double counting.

III..8.1. Biodiversity

The financial needs assessments under the Convention on Biological Diversity are derived from the obligations of the Conference of the Parties to determine funding requirements that are necessary to assist developing countries in fulfilling their commitments under the Convention over the next replenishment cycle of the Global Environment Facility. The first such assessment was undertaken by a team of five experts during the biennium 2010-2012, which was followed-up and expanded as the first global assessment on biodiversity financing by a high-level panel on global assessment of resources for implementing the Strategic Plan for Biodiversity 2011-2020. Table 5 provides the preliminary results of the two financial needs assessments.

The financial needs assessment to determine funding requirements that are necessary to assist developing countries in fulfilling their commitments under the Convention over the sixth replenishment cycle of the Global Environment Facility (2014-2018) was limited to the financial needs of developing countries and countries with economies in transition that are in receipt of financial support from the Global Environment Facility for the specific period of time 2014-2018. Based on the Strategic Plan for Biodiversity 2011-2020 and associated Aichi targets, the needs assessment was focused on programmes/projects/activities that are included in the guidance of the Conference of the Parties to the Convention and are considered as eligible for funding under the financial mechanism of the Convention. Three scenarios or levels of ambition (low, medium, and high) were presented, and potential overlaps were minimized by cross-examination. The total financial needs of recipient countries were estimated to be in the range between US$74 billion and US $192 billion, of which US$ 7-17 billion may be eligible for support by the Global Environment Facility, depending on co-financing ratios applied.

The first global assessment on biodiversity financing by a high-level panel on global assessment of resources, involving wider expertise, was also focused on the Strategic Plan for Biodiverstiy 2011-2020 and associated Aichi targets. It was organized around eleven clusters: awareness raising (Target 1), macroeconomics (Targets 2, 3, 4), forestry (Targets 5, 7, 11, 15), water, pollution and ecosystem services (Targets 5, 8, 14), marine (Targets 6, 7, 10 and 11), agriculture (Target 7), invasive alien species (Target 9), protected areas (Target 11), protected areas and species (Targets 11,12), genetic diversity (Target 13), and enabling actions (Targets 16 to 20). A broad global programme of activity consistent with meeting the Targets was defined, and two scenarios (with lower and higher resource requirements) of the investment and ongoing expenditure required to meet the Targets were presented. The financial needs for the implementation of activities required to achieve the 20 Aichi Targets in all countries were estimated at between **US$153 billion and US$436 billion per year**.

The costing of achieving global biodiversity targets could have benefitted from a direct link with the estimation of economic benefits, in order to provide convincing evidence for enabling informed decisions. The latter was pursued separately, for instance, by The Economics of Ecosystems and Biodiversity (TEEB) Initiative (TEEB, 2009a, 2009b). Other studies have examined the cost of failing to halt the losses of biodiversity and ecosystem resources (e.g. Braat and ten Brink, 2008).

The financial needs assessments had an underlying assumption of business as usual in other segments of the society. If the global sustainable development agenda makes progress in tandem with the global biodiversity targets, the financial needs of achieving the Aichi targets can be reduced substantially. For instance, if countries undertake environmental fiscal reforms and make economic incentive systems consistent with sustainable development goals in general and biodiversity objectives in particular, much funding needs estimated under goals 1 and 2 of the Strategic Plan for Biodiversity 2011-2020 can be eliminated or reduced.

Table 5. Preliminary results of the financial needs assessments under the Convention on Biological Diversity

TARGETS	Funding needs of developing countries and countries with economies in transition (2014-2018) (US$ million)	Average annual expenditure of all countries (2013 – 2020) (US$ million)
GOAL A: Mainstreaming Biodiversity (T 1-4)	138 - 428	562 - 1,343
Target 1: Awareness raising	24 - 72	280 - 890
Target 2: Biodiversity values	7 - 35	100 – 160
Target 3: Incentives	100 - 300	170 – 270
Target 4: Sustainable production/consumption	7 - 21	12 – 23
GOAL B: Reduction of Pressure on BD (T 5-10)	22,487 - 66,211	128,080 - 297,930
Target 5: Reducing habitat loss (forests and wetlands)	2,092 - 5,186	39,200 - 52,100
Target 6: Fisheries	10,025 - 30,075	16,900 - 40,000
Target 7: Sustainable Agriculture, Aquaculture and Forestry	10,200 - 30,600	13,200 - 13,600
Target 8: Pollution		35,400 - 139,200
Target 9: Invasive Alien Species	50 - 150	23,300 - 52,900
Target 10: Coral Reefs	120 - 200	80 - 130
GOAL C: Safeguarding Ecosystems (T 11-13)	39,115 - 88,345	12,680 - 89,990
Target 11: Protected Areas	39,000 - 88,000	9,200 - 85,000
Target 12: Species conservation	100 - 300	3,400 - 4,800
Target 13: Genetic Diversity	15 - 45	80 - 190
GOAL D: Enhancing the Benefits to All (T 14-16)	12,120 - 36.280	10,157 - 43,939
Target 14: Ecosystem Services	60 - 180	3,750 - 37,500
Target 15: Ecosystem Resilience	12,060 – 36,100	6,400
Target 16: Access and benefit sharing		7 – 39
GOAL E: Enhancing Implementation (T 17-20)	46.50 - 141.50	1,864 - 2,640
Target 17: National biodiversity strategies and action plans	25 - 75	50 - 170
Target 18: Traditional Knowledge	12.50 - 37.50	210 - 340
Target 19: Science base	3 - 9	1,600 - 2,100
Target 20: Resource Mobilization	6 - 20	4 - 30
Biosafety	170	
Total	**74,076.50 - 191,575.50**	**153,343 - 435,842**

Source: CBD Secretariat, compilation from CBD (2012a) and CBD (2012b).

Although the financial needs assessments presented scenarios based on levels of ambition, the assessments did not undertake any sensitivity test. If the underlying assumptions are to change, the estimated results can also vary considerably. For instance, if climate change moves to the direction of worst-case scenario, the cost of biodiversity adaptation can increase significantly. Other external shocks, such as disasters and less biodiversity-friendly national policies, can also increase funding burdens for achieving the global biodiversity targets.

III.8.2. Forests

A report by UNFF (2012), building on previous studies, estimates that global funding requirements for sustainable forest management between US$70 billion to US$160 billion per year. The report does not detail how these estimates are calculated.

Generally speaking, the estimates on forest finance have come from two tracks of work: climate change and biodiversity.

Forestry is an important sector for climate change mitigation and adaptation. An analysis of the investment needs and mitigation potential for activities that increase CO_2 sinks through agroforestry was conducted by UNFCCC (2007). The analysis only covered the investment and financial flows needed by non-Annex I Parties of UNFCCC. The specific goals for the forest sector to achieve in 2030 are: 1) reducing deforestation/ forest degradation to zero by 2030 (from an average rate of 12.9 million ha per year); 2) achieving sustainable forest management on 602 million ha of tropical production forest and temperate and boreal forests; and 3) expanding agroforestry by 19 million ha per year. The reference scenario assumes that GHG emissions from the forestry sector in 2030 will be the same as in 2004. The mitigation scenario includes potential sinks created through reduced deforestation, forest management and afforestation and reforestation. The estimates for this study are based on an analysis of resource requirements of different mitigation measures, based on estimated opportunity costs and forest management costs.

The UNFCCC analysis suggests that total forest financing requirements on the order of **US$43 billion per year**, the vast majority of which would come from domestic sources, both public and private. The investment need breakdowns are as follows:

Table 6: Breakdowns of Forest Finance in UNFCCC study

Forest Targets	Incremental investment	Method
Reducing deforestation/ forest degradation to zero by 2030	Annual cost of US$12.2 bn (US$945.7 per ha)	Opportunity cost
Achieving sustainable forest management on 602 million ha of production forest in tropical and subtropical areas, and 50 million ha of temperate and boreal forests	US$7.2 bn per year for non-Annex I Parties in tropical and subtropical areas	Unit cost estimates based on Whiteman (2006)
	US$1 bn per year for non-Annex I Parties with temperate and boreal forests	
Expanding agroforestry by 19 million ha per year	Annual investment of US$15bn (US$780 per ha)	OECD ENV-Linkages model
	Operating costs of US$8 bn per year (US$440 per ha)	
Grand Total	**US$43.4 bn**	

Source: Author's elaboration, adapted from UNFCCC (2007).

Another global assessment was conducted by the Informal Working Group on Interim Finance for REDD+ (IWG-IFR) in 2009 in the context of UNFCCC. 43 developing countries were included in this funding analysis. IWG-IFR estimated the resource requirement to achieve the following two goals: 1) 25 per cent reduction in annual global deforestation and degradation rates by 2015 compared with the 2000-05 average (approximately 3 million ha by 2015); and 2) establishment of a result-based incentive structure that rewards countries for reducing emissions from deforestation and forest degradation relative to an agreed national reference level.

According to this study, if financing of €15-20 billion could be made available for the 2010-15 period for result-based incentives and capability building, complementing other REDD+ efforts, the objective of 25 per cent reduction in global deforestation rates would be achievable by 2015. At the exchange rate of $1.28/ Euro, this is equivalent to US$4– 5 billion per year.

Another source of reference on 'costing' forests is from the Report by the High-level Panel for CBD (2012, see above). The total funding estimates from this Report for *forest components* of the Aichi targets were on the order of **US$40 billion per year**.

III.8.3. Oceans

To our knowledge, there does not exist a comprehensive assessment of investment requirements for the sustainable management of oceans. Global estimates have been produced for specific activities (see below). Due to multiple feedbacks to and from other sectors (e.g. agriculture, industrial pollution, climate change, coastal erosion), any estimate would likely be highly sensitive to outcomes observed in other sectors.

On the other hand, there have been a number of estimates of the economic losses stemming from unsustainable management of global marine fisheries and from the impacts on oceans of climate change and pollution. For example, the joint FAO-World Bank report *Sunken Billions* reviews previous estimates of economic losses from unsustainable fisheries ranging between US$46 billion and US$90 billion annually (FAO and World Bank, 2009).

UNDP-GEF (2012) provided an assessment of resource needed for catalyzing ocean finance to achieve the following four objectives: 1) reduce nutrient over-enrichment of coastal areas; 2) improve energy efficient shipping and protect/ restore coastal carbon sinks; 3) reduce unsustainable fishing practices; and 4) reduce aquatic species transfer via ship hull fouling. Drawing from past UNDP-GEF projects, these objectives are 'disaggregated' into required policy interventions aimed at catalyzing private finance.[7] In the UNDP-GEF projects, those interventions were financed by public resources. The report estimates the amount of public and private funds that were mobilized after the policy changes occurred. Global estimates of potential private finance mobilization in these activities are obtained by extrapolation, applying the ratios observed for the UNDP-GEF project to global needs. Using this methodology, the report estimates that an initial public investment of US$5 billion over the next 10-20 years at the global level to address hypoxia, ocean acidification, overfishing, and marine invasive species respectively could catalyze around **US$35 billion per year**, mostly from private sources.

Other estimates come from the report of the High-level Panel for the Convention on Biological Diversity "Resourcing the Aichi Biodiversity Targets" mentioned above (CBD, 2012). The Aichi Biodiversity Targets include specific targets on oceans.[8] Specifically, targets 6), 10), and 11) are ocean-related. Activities considered in the costing of those targets include integrated coastal zone management, sustainable marine resource use (e.g. fisheries), integrated watershed and wastewater management, and use of marine protected areas to conserve biodiversity, habitats and exploited populations. The scope is

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[7] For example, to reduce nutrient loading of coastal areas, various policies have to be put in place, such as nutrient management regulations, nutrient emissions cap and trade in river basins, fertilizer subsidy reform, etc.

[8] For instance, Aichi Target 10 states that by 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

therefore close to that of the UNDP-GEF report. Summing up the investment needs estimates associated with ocean-related Aichi Targets leads to a total of **US$39 billion per year** for all countries from 2013 to 2020.

III.9. Integrated sustainable development scenarios

As described above, a number of integrated scenarios for sustainable development have explored pathways that would allow humanity to meet selected sustainability targets. The main conclusions from a review of sustainability scenarios produced for Rio+20 is presented in Box 1.

Box 1: Lessons from a review of sustainable development scenarios produced for Rio+20

A review of mainstream sustainable development scenarios undertaken for Rio+20 revealed the following features, which are relevant to attempts to estimate financing needs for sustainable development.

High level of agreement on overall scenario conclusions
Despite their variety in terms of modelling approach and desired goals, the sustainable development scenarios developed for Rio+20 agree to a large extent in terms of their overall conclusions.
• There are numerous feasible pathways to sustainable development.
• There is no agreement on "must have" lists, but scenarios show the benefits of reining in overall material and energy use, increased end-use efficiency, and reduced poverty.
• A broad pursuit of sustainable development is far superior in performance over pursuing single-issue objectives in isolation (e.g., promote economic growth first and introduce greenhouse gas mitigation policies later).
• Complex trade-offs related to the global commons need to be tackled globally.
• While sustainability goals put forward by politicians have become increasingly ambitious, their attainment has become increasingly difficult.
• Education, RD&D and population goals are essential, with very large synergies with the development and environmental dimensions.

Little agreement on specific policy suggestions
There is no single solution or policy for sustainable development. Bottom-up measures and policies need to be tailored to each issue, country, and sector. Great differences remain in terms of specific policy recommendations that are drawn ex-post from scenario results. A key problem is the existence of important trade-offs across time, sectors, and issues.
Scenarios produced for Rio+20 also highlight the equally important synergies and opportunities provided by policy strategies that are geared to simultaneous achievement of multiple sustainable development goals.

A call for caution
Many "green" scenarios are unsustainable in at least one or more dimensions. None of the mainstream scenarios for Rio+20 illustrate a path toward sustainable development in 2050 that would satisfy the full set of sustainable development goals suggested by science. Proposed "solutions" are often inconsistent across sectors. For example, all the mainstream sustainable development scenarios for Rio+20 see substantial increases in biofuel production and deployment of modern renewables, and consequently lead to significantly increased water and land use, increased water stress for the majority of the world population, as well as anthropogenic interference with phosphorus and nitrogen flows at a level that has been deemed incompatible with planetary limits by global environmental science.
The SD21 study on scenarios also confirmed that sectoral scenario studies (e.g., those on food, water, forests, or development), as well as national integrated studies, are mostly carried out in isolation from integrated global scenario studies. Hence, while these national and sectoral studies highlight ways of overcoming some of the local and sectoral trade-offs, by design they cannot fully account for feedbacks and constraints across sectors or regions.

Source: SD21 summary for policymakers, UNDESA, 2012.

Few independent scenario reports provide estimates of investment needs for a comprehensive set of goals in their flagship reports or publications, even though figures may often be generated by the models and may be available in technical annexes. Some integrated models provide very detailed estimates of investment requirement on the energy sector (e.g. GEA, 2012). Many integrated scenarios do not provide estimates for infrastructure other than energy infrastructure.

Table 7: Select Estimates of Financing Needs Associated with a Low-carbon Economy Transition

Source	Estimate	Coverage	Comments
UNDESA, World Economic and Social Survey (WESS) (2011)	USD 1.1 trillion per annum over 2000 – 2050	Incremental investment to achieve sustainable development targets in developing countries.	Study assumes that 60% of global expenditure requirements are in developing countries. Global estimates based on results of a range of studies. Targets in sectors covered by the estimates are: • Energy supply and end use efficiency to stabilise greenhouse gas concentrations to < 2° C (with at least 50% probability) • Adaptation: minimum investments in securing livelihoods, assuming successful mitigation. • Agriculture and food: increasing agricultural yields to ensure global food security without further expanding agricultural land (developing countries only). Does not include estimates for other major uses such as sustainable freshwater management, forestry, fisheries etc.
UNEP, Green Economy Report (2011)	2% global GDP per annum over 2000 – 2050 (~USD 0.78 trillion in 2010)	Additional investments in "green economy" activities	Both Green Economy and business-as-usual (BAU) scenarios *assume* an increase in investment of 2% global GDP (USD 1.3 trillion in 2010). The Green Economy scenarios allocate this investment across green activities in the following sectors: energy (15-26%), transport (16-17%), buildings (10%), waste (8-10%), agriculture (8-10%), tourism (9-16%), fisheries (8-10%), water (8-10%) and forests (2-3%). BAU scenarios allocate the same portion of GDP to additional investment, according to existing patterns.
PBL report to the Club of Rome (2009)	USD 400-1600 bn per year	Additional investment in energy systems needed to comply with a 2 degree target, 2000-2050.	This is in addition to a baseline of about USD 1400 billion per year. The numbers are a mix of previously published estimates.
	USD 30 bn per year	Annual investment needed to achieve high yields necessary to avoid increase in agricultural land use, 2000-2050.	The report is unclear on how the numbers were derived. This is in addition to a baseline of about USD 200 billion per year.
	USD 50-160 billion per year	Adaptation to climate change	The report is unclear on how the numbers were derived. They may be based on UNFCCC (2007).

Source: Authors' elaboration.

The main focus of the report done by PBL for the club of Rome (PBL, 2009) is on climate change mitigation and biodiversity conservation. The report also considers needed investment in agriculture in order to avoid expansion of arable land (this is taken as a proxy measure for protecting biodiversity). The overall conclusion of the report is that investments to reduce greenhouse gas emission by 50% by 2050, mitigate climate change and protect biodiversity amount to about 2% of GDP in 2050. The estimates do not distinguish between public and private finance. The report is unclear on how the estimates are obtained, and highlights their high uncertainty (PBL, 2009).

The 2012 World Economic and Social Survey (UNDESA, 2012) presents estimates of additional investments in energy supply and end use, for climate change adaptation, and for increasing agricultural yields to ensure global food security without further expanding agricultural land. Estimates are based on various sources, including PBL (2009).

Lastly, in its modeling for the Green Economy Report, UNEP assumes both a target level of additional investment (2% of GDP annually) and the sectoral allocation of additional investment in "green economy" activities. The study then contrasts the economic, social and environmental outcomes of the scenarios (UNEP, 2012). The methodology used differs from other scenario modelling exercises in that respect. In the latter the allocation of investments across sectors and technologies is derived endogenously.

IV- . Financing needs for countries in special situations (LDCs, SIDS, LLDCs)

Least developed countries (LDCs), landlocked developing countries (LLDCs) and small island developing states (SIDS) are the 92 most vulnerable member states of the United Nations.[9] On average they experienced relatively high GDP growth over the past decade and made some progress towards achieving the MDGs, though less than in other groups of countries. In addition, much of this growth was jobless and their economic structure has been mostly unchanged. Their production and export structures are still highly concentrated on primary commodities and in some cases on low value-added manufacturing and services. In addition, they are highly dependent on aid. Furthermore their marginalization in the global economy is exacerbated by their geographical handicaps, including small size, remoteness and prohibitive trade transaction costs, especially for LLDCs and SIDS. Thus they are disproportionally affected by the multiple crises, especially high and volatile food and energy prices and the effects of climate change to which they did not contribute.

LDCs, LLDCs and SIDS and their special needs are all specifically mentioned in the Millennium Declaration.[10] For LDCs special focus is given to market access, debt relief and development assistance. For SIDS it urges the international community to take into account their special needs in the development of a vulnerability index, and for LLDCs increased financial and technical assistance to help them overcome the impediments of geography by improving their transit transport systems are highlighted. Consequently ODA to LDCs, LLDCs and SIDS as well as duty free market access for LDCs are included in MDG 8.

Specific financing needs of LDCs, LLDCs and SIDS[11]

Due to the specific development challenges that LDCs, LLDCs and SIDS are facing, their financing needs to achieve economic, social and environmentally sustainable development are disproportionally large, at least as a share of their GDP. Rough OHRLLS estimates put the financing gap of LDCs at $75 billion a year if these countries are to grow--on average--by 7% over the next 10 years (UN-OHRLLS, 2011). In many cases funding for the required investments will have to come mostly from ODA, as these countries do not have easy access to other sources of financing such as trade and FDI.

There are no estimates of financing gaps to achieve the MDGs or sustainable development in a broader sense that directly apply to the three categories of countries with special needs. However, the estimates for regional or income groups with a large overlap with the LDCs, LLDCs and SIDS can serve as a proxy,

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[9] These 92 member states are 49 LDCs + 15 non LDC-LLDCs (out of 31 LLDCs) + 28 non LDC-SIDS (out of 38 SIDS).

[10] A/RES/55/2, paragraphs 15, 17 and 18.

[11] In the discussion on a post-2015 development agenda, the special needs of countries in conflict or emerging from conflict have been highlighted. Many of these countries belong to the LDC category.

thus some recent estimates are provided below. In any case estimates of financing gaps rather give an indication of the order of magnitude and are not comparable as different goals are covered.

Financing gap estimates for low income countries (LICs) include $120-160 per capita annually towards the end of the period before 2015 to meet the MDGs and that 10-20% of GDP would need to be provided in ODA (UN, 2012b). An OECD study estimates that $62 billion per year are needed to cover the financing gap to reach MDGs 1-6 in 20 LICs. At the same time they estimate the potential increase of tax revenue for these countries to be around $3 billion (Atisophon et al, 2011).

Fourty LDCs, LLDCs and SIDS are among the 47 sub-Saharan African countries. Several estimates of financing gaps in that region for different sectors include the following:

- $31 billion per year for infrastructure, mainly power (Foster and Briceño-Garmendia, 2010)
- Achieving universal access to modern energy services by 2030 will require around $25 billion a year in investment (IEA 2012).
- The World Bank estimated that roughly $18 billion (in 2005 prices) would be needed per annum to adapt to climate change in Africa (World Bank, 2013).

Recent estimates of public investment needs to deliver a package of policies to promote inclusive and sustainable development in Asia Pacific countries show that its cost is projected to exceed 10% of GDP by 2030 in Fiji (13%) and Bangladesh (22%).[12] By contrast the median value of required investments by 2030 is 8.2% of GDP. This suggests that domestic resources of economies with special needs, such as SIDS and LDCs will not be sufficient to finance such a comprehensive package (ESCAP 2013).

The high vulnerability of LDCs, LLDCs and SIDS to economic shocks and climate change also causes additional expenditure for resilience building and disaster risk reduction. Risk mitigation schemes need to be developed with adequate financial means. This is especially relevant for small island economies, where the cost of damage caused by natural disasters can easily be higher than the annual GDP. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is one example. Countries buy coverage for a given year up to $100 million. Although the amount of financial resources provided is relatively small, it is disbursed fast and can be used according to government priorities. The pooling of risks among members lowers the cost of coverage by more than 50%. An extension of such a risk mitigation scheme in other regions would also need to be financed partly with external funds. To cover 16 Caribbean countries $76 million was provided by several donors over 4 years.

[12] The package includes a job guarantee programme, a universal non-contributory pension, benefits for all persons with disabilities, increasing the share of public health expenditure of GDP to 5% by 2013 and three energy goals.

V- References

AFD and World Bank, 2010, Africa's Infrastructure: A Time for Transformation, V. Foster and C. Briceño-Garmendia, eds., Washington, DC.

Akimoto, K. et al. 2012. "Consistent assessments of pathways toward sustainable development and climate stabilization", *Natural Resources Forum* 36: pp.231-44.

Atisophon V., J. Bueren, G. De Paepe, C. Garroway and J. P. Stijns. 2011. *Revising MDG Cost Estimates from a Domestic Resource Mobilization Perspective*. OECD Development Centre Working Paper No. 306, OECD.

Asian Development Bank, 2012, *Infrastructure for Supporting Inclusive Growth and Poverty Reduction in Asia.* Mandaluyong City, Philippines.

Bhattacharyay, B.N. 2010, Estimating Demand for Infrastructure in Energy, Transport, Telecommunications, Water and Sanitation in Asia and the Pacific: 2010–2020., *ADB Institute Working Paper Series*. No. 248. Tokyo: Asian Development Bank Institute.

Battacharya, A. M Romani,. N. Stern, (2012) 'Infrastructure for Development: Meeting the Challenge'. CCCEP, Grantham Research Institute on Climate Change and the Environment and G24.

Bourguignon, F., C. Diaz-Bonilla and H. Lofgren. 2008. *Aid, service delivery, and the Millennium Development Goals in an economy-wide framework*. Policy Research Working Paper Series, No. 4683, World Bank, Washington, DC.

Braat, I and P. Ten Brink (eds), 2008, The cost of policy inaction: the case of not meeting the 2010 biodiversity target, Wageningen /Brussels.

CBD (2012a), "Full Assessment of the Amount of Funds Needed for the Implementation of the Convention for the Sixth Replenishment Period of the Trust Fund of the Global Environment Facility: an assessment by the CBD Expert Team Members", Ad Hoc Open-ended Working Group on Review of Implementation of the CBD, May, Montreal. http://www.thegef.org/gef/sites/thegef.org/files/documents/document/cop-11-inf-35-en.pdf

CBD (2012b), *Resourcing the Aichi Biodiversity Targets: A first assessment of the resources required for implementing the strategic plan for biodiversity 2011-2020*, Report of the High-level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011-2020. http://www.cbd.int/doc/meetings/fin/hlpgar-sp-01/official/hlpgar-sp-01-01-report-en.pdf

CLIMATE FINANCE / Green Climate Fund – Background Note, provided by Tracy Raczek, Secretary-General's Climate Change Support Team, on 24 May 24, 2013

Commission on Macroeconomics and Health, 2001, *Macroeconomics and Health: Investing in Health for Economic Development*, Report of the Commission on Macroeconomics and Health, http://whqlibdoc.who.int/publications/2001/924154550x.pdf, Accessed 10 May 2013.

Delamonica E., S. Mehrotra, J. Vanemoortele. 2001. "Is EFA affordable? Estimating the global minimum cost of 'education for all'", *Innocenti Working Papers* No 87, UNICEF. http://www.unicef-irc.org/publications/pdf/iwp87.pdf

Devarajan, S., M. J. Miller and E. V. Swanson. 2002. *Goals for Development: History, Prospects, and Costs*. Working Paper No.2819, World Bank, Washington, DC.

Estache, A. (2010). Infrastructure Finance in Developing Countries: An Overview, EIB Papers, European Investment Bank, Economics Department.

ESCAP, 2013, *Economic and social survey of Asia and the Pacific 2013 – Forward-looking Macroeconomic Policies for inclusive and sustainable development*, Bangkok.

FAO, 2009, How to Feed the World 2050, FAO High-Level Expert Forum 12-13 October 2009. FAO, Rome, available at; http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

FAO, 2013, *The State of Food and Agriculture 2013, Food Systems for Better Nutrition*., FAO, Rome.

Fay, M., A. Iimi, and B. Perrissin-Fabert, 2010. *Financing Greener and Climate Resilient Infrastructure in Developing Countries: Challenges and Opportunities*., EIB Papers 15 (2): 35–59.

Fay, M., M. Toman, D. Benitez and S. Csordas (2011), Infrastructure and Sustainable Development. In: Fardoust, Shahrokh,Yongbeom Kim, and Claudia Paz Sepúlveda (eds.) *Postcrisis Growth and Development: A Development Agenda for the G-20*.

Fischedick, M., R. Schaeffer, A. Adedoyin, M. Akai, T. Bruckner, L. Clarke, V. Krey, I. Savolainen, S. Teske, D. Urge-Vorsatz, R. Wright, 2011, Mitigation Potential and Costs, in IPCC Special report on Renewable Energy sources and climate Change Mitigation, Cambridge University Press, Cambridge , UK, and New York, USA.

Foster, V., C. Briceño-Garmendia, 2010: *Africa's Infrastructure*, The World Bank.

Grown, Caren, Chandrika Bahadur, Diane Elson and Jessie Handbury (2008), "The Financial Requirements of Achieving Gender Equality and Women's Empowerment", in Mayra Buvinc, Andrew Morrison, A. Waafus Ofosu-Amaah, and Mirja Sjoblom (eds), *Equality for Women: Where do We Stand on Millennium Development Goal 3?* World Bank, Washington, D.C.

IIASA (International Institute for Applied Systems Analysis). 2009. "GGI Scenario Database." Luxemburg, Austria.

IIASA (2012). *Global Energy Assessment: Toward a Sustainable Future.* Cambridge University Press. http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Global_Energy_Assessment_FullReport.pdf

IEA (2013) Global Land Transport Infrastructure Requirements: Estimating road and railway infrastructure capacity and costs to 2050, John Dulac et al, http://www.iea.org/publications/freepublications/publication/TransportInfrastructureInsights_FINAL_WEB.pdf

IEA (International Energy Agency), 2012. *World Energy Outlook 2012,* Paris: IEA.

IEA (International Energy Agency), 2011. *World Energy Outlook 2011,* Paris: IEA.

IEA (International Energy Agency). 2008. *Energy Technology Perspective 2008: Scenarios and Strategies to 2050*. Paris: IEA.

IEA (2010) *Energy Technology Perspectives: Scenarios & Strategies to 2050.* http://www.iea.org/publications/freepublications/publication/etp2010.pdf

International Energy Agency (IEA), 2009, *World Energy Outlook 2009*, OECD, Paris. Available at: http://www.worldenergyoutlook.org/media/weowebsite/2009/WEO2009.pdf

IPCC. 2007. Summary for policymakers. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* B. Metz, O.R. Davidson, P.R. Bosch, R. Davie, L.A. Meyer eds., Cambridge University Press Cambridge, UK.
Heuty, A. 2009. "Overview of MDG Costing Methodologies", UNDP.

IWG/IFR (2009). Report of the Informal Working Group on Interim Finance for REDD+, Discussion Document. Available at:
http://www.regjeringen.no/upload/MD/Vedlegg/Klima/klima_skogprosjektet/iwg/Report%20of%20the%20Informal%20Working%20Group%20on%20Interim%20Finance%20for%20REDD+%20_IWG%20IFR_Final.pdf

Kennedy, C., J. Corfee-Morlot, 2013, Past performance and future needs for low carbon climate resilient infrastructure– An investment perspective, *Energy Policy*, 59, *773-783.*

Kharas, H. and A. Rogerson. 2012. *Horizon 2025: creative destruction in the aid industry*, Overseas Development Institute, July 2012.

Kumaranayake L, Kurowski C, Conteh L, 2001, Costs of Scaling up Priority Health Interventions in Low Income and Selected Middle Income Countries, Methodology and Estimates, *CMH Working Paper Series Paper No. WG5: 18*, Commission on Macroeconomics and Health, http://library.cphs.chula.ac.th/Ebooks/HealthCareFinancing/WG5/Paper%20no.WG5_18.pdf, Accessed 10 May 2013.

Markandya, A., S. Setboonsarng, Q. Y. Hui, R. Songkranok, and A. Stefan. 2010. *The Costs of Achieving the Millennium Development Goals through Adopting Organic Agriculture*. ADBI Working Paper 193. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/working-paper/2010/02/09/3455.cost.mdg.organic.agriculture/

McKinsey Global Institute, 2013, *Infrastructure Productivity: How to save $1 trillion a year*, McKinsey Infrastructure Practice, January.

McKinsey & Company (2009), 'Pathways to a Low-carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve', McKinsey & Company.
http://www.epa.gov/statelocalclimate/documents/pdf/mckinsey_summary_11-19-09.pdf

Olbrisch, S., E. Haites, M. Savage, P. Dadhich, M. K. Shrivastava, 2011, Estimates of incremental investment for and cost of mitigation measures in developing countries, *Climate Policy*, 11, 970-986.

Organisation for Economic Co-operation and Development (OECD), 2012, *Can we still Achieve the Millennium Development Goals? From Costs to Policies*. Development Centre Studies, OECD Publishing.

Parry, M., N. Arnell, P. Berry, D. Dodman, S. Fankhauser, C. Hope, S. Kovats, R. Nicholls, D. Satterthwaite, R. Tiffin, T. Wheeler, 2009, *Assessing the costs of adaptation to climate change: A review of the UNFCCC and other recent estimates*, IIED, London.

Pettifor, A. and R. Greenhill. 2002. *Debt Relief and the Millennium Development Goals*. Background paper for the Human Development Report 2003, UNDP.

The Pew Charitable Trusts, 2010. *Global Clean Power: A $2.3 Trillion Opportunity,* Philadelphia: The Pew Charitable Trusts.

PBL. 2009. *Growth within Limits*. A Report to the Global Assembly 2009 of the Club of Rome. Netherlands Environmental Assessment Agency. Available at:
http://www.rivm.nl/bibliotheek/rapporten/500201001.pdf

Rao, S. 2009. *Investing in a Climate Friendly Futur*e. IIASA, Luxembourg. Austria.

Reddy, S. and A. Heuty. 2005. *Peer and Partner Review: A Practical Approach to Achieving the Millennium Development Goals*. Journal of Human Development and Capabilities, Vol. 6, No. 3.

Reddy, S. and A. Heuty. 2006. Achieving the Millennium Development Goals: What's Wrong with Existing Analytical Models?, *DESA Working Paper*, No. 30, United Nations, New York.

Rockström, J., *et al.,* 2009, A safe operating space for humanity, *Nature,* 461, 23 September.

Roehrl, Richard A., 2013, *Sustainable development scenarios for Rio+20. A Component of the Sustainable Development in the 21st Century (SD21) project*, New York, United Nations Department of Economic and Social Affairs.

Roques, F., O. Sassi, 2008. "A hybrid modelling framework to incorporate expert judgment in integrated economic and energy models – The IEA WEM-ECO model." Available from http://www.environnement.ens.fr/IMG/Poster%20Governing%20by%20Scenarios%20Goebel.pdf.
Project Catalyst. 2009. *Adaptation to Climate Change: Potential Costs and Choices for a Global Agreement*. London: Climate Works and European Climate Foundation.

Sachs, J. and J. W. McArthur. 2005. *The Millennium Project: a plan for meeting the Millennium Development Goals*. The Lancet, January 12, 2005, pp. 347–53, Available: http://image.thelancet.com/extras/04art12121web.pdf

Sánchez, M. V., R. Vos, K. Inoue and D. Kabulova. 2013. *Financing Human Development: a comparative analysis*. *In* Sánchez, M. V. and R. Vos (eds.), "Financing Human Development in Africa, Asia and the Middle East", Bloomsbury Academic-United Nations, 2013.

Schmidhuber, J., J. Bruinsma. 2011, Investing towards a world free of hunger: lowering vulnerability and enhancing resilience, In A. Prakash (ed), *Safeguarding Food Security in Volatile Global Markets*, FAO, Rome.

Schmidhuber, J., J. Bruinsma and G. Boedeker. 2009, Capital requirements for agriculture in developing countries to 2050, paper presented at the FAO Expert Meeting "How to Feed the World in 2050", FAO, Rome, available at: http://www.fao.org/waicent/faoinfo/economic/esd/Capital-requirements-agriculture.pdf

SEI, 2012, *Energy for a Shared Development Agenda: Global Scenarios and Governance Implications*, June, Stockholm Sweden.

Singh, S., J. Darroch, L. Ashford, M. Vlassoff, 2009, Adding It Up: The Costs and Benefits of Investing in Family Planning and Maternal and Newborn Health, Guttmacher Institute.

Stanton, E. and F. Ackerman. 2009. "Climate and Development Economics: Balancing science, politics and equity". *Natural Resources Forum*, vol.33, pp.262-73.

Stern, N. 2007. *Stern Review: the Economics of Climate Change*. The UK Her Majesty's Treasury, Cambridge: Cambridge University Press.
TEEB, 2009a, *The Economics of Ecosystems and Biodiversity for National and International Policy Makers* - Summary: Responding to the value of nature 2009.

Stenberg K, Johns B, Scherpbier RW, Tan-Torres Edejer T, 2007, A Financial Road Map to Scaling Up Essential Child Health Interventions in 75 Countries, *Bulletin of the World Health Organization*, April, 85 (4) http://www.who.int/bulletin/volumes/85/4/06-032052.pdf Accessed 10 May 10, 2013

TEEB, 2009b, The Economics of Ecosystems and Biodiversity for National and International Policy Makers, Chapter 9: Recognizing the value of protected areas.

Thomson Reuters Foundation, 2013, "Green Climate Fund must keep gender equality promises", 7 May 2013, http://www.trust.org/item/20130307141500-zi3hk/?source=spotlight

United Nations, 2012, *The Future We Want*, United Nations Conference on Sustainable Development Outcome Document:. A/CONF.216/L.1, 19 June.

United Nations, 2012b: *MDG Gap Task Force Report* - The Global Partnership for Development: Making Rhetoric a Reality

United Nations, 2002, Johannesburg Declaration and Plan of Implementation, adopted at the United Nations World Summit on Sustainable Development, New York.

United Nations, 2001, *Report of the High-level Panel on Financing for Development,* ("Zedillo Report"). New York: United Nations.

United Nations Economic Commission for Latin America and the Caribbean, 2013, *Sustainable Development in Latin America and the Caribbean. Follow-up to the United Nations development agenda beyond 2015 and to Rio+20*. United Nations, March 2013. Available: at http://www.eclac.cl/rio20/noticias/paginas/6/48936/2013-123-Sustainable_development_WEB.pdf.

United Nations Millennium Project. 2005. *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals*. Available: http://www.unmillenniumproject.org/reports/fullreport.htm

UNDESA, 2012, Sustainable Development in the 21st century, 2012, *Review of implementation of Agenda 21 and the Rio Principles, synthesis report,* report produced by Stakeholder Forum, New York, January.

UNDESA, 2012b, *Sustainable Development in the 21st century, summary for policy-makers*, Division for Sustainable Development, New York, available at http://sustainabledevelopment.un.org/content/documents/UN-DESA_Back_Common_Future_En.pdf.

UNDESA (2011): Report of the Expert Group Meeting on Sustainable Development Scenarios for Rio+20, Vienna/Laxenburg, 27-29 June 2011, http://sustainabledevelopment.un.org/content/documents/1112reportvienna.pdf

UNDP-GEF (2012). *Catalyzing Ocean Finance Volume I Transforming Markets to Restore and Protect the Global Ocean*. New York, USA. Available at: http://www.undp.org/content/undp/en/home/librarypage/environment-energy/water_governance/ocean_and_coastalareagovernance/catalysing-ocean-finance/

UNEP. 2012. *Green Economy Report.* http://www.unep.org/greeneconomy/greeneconomyreport/

UNEP, 2012, *Financing renewable energy in developing countries,* UNEP Finance Initiative, Geneva.

UNFCCC (2007). *Investment and Financial Flows to Address Climate Change*. Bonn, Germany. Drawn on the Fourth Assessment Report (AR4) of the IPCC, the World Energy Outlook (WEO) of the International Energy Agency (IEA), and the Stern Review. Available at: http://unfccc.int/resource/docs/publications/financial_flows.pdf

UNFF (2012) *2012 Study on Forest Finance,* the United Nations Forest Forum (UNFF) Advisory Group on Finance (AGF) Collaborative Partnership on Forest, June. Available at: http://www.un.org/esa/forests/pdf/AGF_Study_July_2012.pdf

UN-OHRLLS, 2011, Resource Requirements in LDCs based on OHRLLS' staff Estimates, mimeo

Vos, R., M. V. Sánchez and C. Kaldewei. 2010. *Latin America and the Caribbean's Challenger to reach the MDGs: financing options and trade-offs. In* Sánchez, M. V., R. Vos, E. Ganuza, H. Lofgren and C. Diaz-Bonilla (eds.), "Public Policies for Human Development. Achieving the Millennium Development Goals in Latin America", Palgrave Macmillan–UNDP–UNDESA–The World Bank, UNOPS 2010.

Whiteman, Adrian (2006) "Financing sustainable forestry in the tropics: a global overview". Presentation at the International Tropical Forest Investment Forum: issues and opportunities for investment in national tropical forests. Cancun, Mexico.
Available at: http://www.itto.int/direct/topics/topics_pdf_download/topics_id=12130000&no=121

WHO, 1978, Declaration of Alma-Ata International Conference on Primary Health Care, Alma-Ata, USSR, 6-12 September http://www.who.int/publications/almaata_declaration_en.pdf Accessed 10 May 2013.

WHO, 2007, Everybody's Business Strengthening Health Systems to Improve Health Outcomes WHO's Framework for Action, http://www.who.int/healthsystems/strategy/everybodys_business.pdf, Accessed 10 May 2013

WHO, 2008, Ouagadougou Declaration on Primary Health Care and Health Systems in Africa: Achieving Better Health for Africa in the New Millennium, http://www.who.int/management/OuagadougouDeclarationEN.pdf, Accessed 10 May 2013

WHO, 2010, Constraints to Scaling Up the Health Millennium Development Goals: Costing and Financial Gap Analysis: Background Document for the Taskforce on Innovative International Financing for Health Systems, International Health partnership, http://www.internationalhealthpartnership.net/fileadmin/uploads/ihp/Documents/Results___Evidence/HAE__results___lessons/Working%20Group%201%20Technical%20Background%20Report%20%28World%20Health%20Organization%29.pdf

World Bank and FAO (2009) *The Sunken Billions – the economic justification for fisheries reform,* Washington DC, USA. Available at:
http://siteresources.worldbank.org/EXTARD/Resources/336681-1224775570533/SunkenBillionsFinal.pdf

World Bank, 2013, Long-term investment financing for Growth and Development, papers presented to the Meeting of the G20 Ministers of Finance and Central Bank Governors, February. Available at: http://www.g20.org/reports/

World Bank, 2013: Africa's Pulse, April 2013.

Word Bank and IEA, 2013, *Global Tracking Framework,* Sustainable Energy for All, 77889, V.3, Washington, DC.

World Bank and International Monetary Fund, 2011, *Global Monitoring Report 2011. Improving the Odds of Achieving the MDGs. Heterogeneity, Gaps and Challenges*. Washington, DC.

World Bank. 2010. *the Economics of Adaptation to Climate Change*, synthesis report, the World Bank, Washington, D.C.

World Bank (2010), 'The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates', Washington, DC: World Bank. Available on 26/09/2012 at http://siteresources.worldbank.org/EXTCC/Resources/EACC-june2010.pdf.

World Bank, 2008, Africa Infrastructure Country Diagnostic, Overhauling the Engine of Growth: Infrastructure in Africa, Executive summary, Vivien Foster, September 2008, Washington, DC, available at http://siteresources.worldbank.org/INTAFRICA/Resources/AICD_exec_summ_9-30-08a.pdf.

World Bank, 2005, Chatterton, Isabel and Olga Susana Puerto, 2005, Estimation of Infrastructure Investment Needs in the South Asia Region, Washington, DC.

Annex 1: Assessing financing needs for sustainable development: Basic concepts, methods used, and caveats.

Before one can answer the question “how much will it cost?”, one needs to be clear on exactly what has to be estimated and under which assumptions. Concepts such as costs, financing needs, and financing gaps, have been used in various senses, potentially generating confusion. Similarly, a range of estimates on financing requirements applying different assumptions and methodologies for achieving global goals have been estimated over the years. These estimates should therefore be interpreted with care.

Needs: the concept of “needs” can only be understood in relation to norms. Those norms can be those emanating from basic rights or entitlements (for example, the right to food, the right to basic human security, the right to safe drinking water). Such “needs” can be translated into resource requirements for the supply of goods and services necessary to satisfy them. The norms can also reflect goals or commitments. Given assumptions on the strategies (means) to achieve the goals, those can be translated into required investment, income, etc., thus giving monetary estimates of “needs”.

Gap: The concept of “gap” is the difference between the current situation and a desired situation defined as an objective. It can be expressed in physical quantities, in monetary terms, or in more qualitative terms. The term “financing gap” is used to describe the difference between available financing and financing that would be needed to achieve a specific objective.

Box A1. Financing gap: An illustration

The concept of financing gap can be approached at both the macro and micro-economic levels. An example at the micro level would be as follows. Suppose that a country has a deforestation rate of 2,000 hectares per year, and wants to reduce it to 1,000 hectares per year. First, one should identify the factors that determine deforestation (e.g. no legislation, lack of law enforcement, unemployment rate in rural areas, awareness campaigns, etc.). Second, one would quantify the importance of each of those factors in the outcome. Based on the impact of each of the variables, strategy to reduce deforestation by the desired amount (50%) can be developed. Then, the cost of implementing such strategy would be translated into monetary terms. The financing gap is derived by comparing the level of resources that would be necessary relative to the level of funds currently available. In this example, suppose that regular awareness campaigns were the only variable reducing deforestation. If to achieve the 50% reduction requires to implement such campaigns every three months, but public authorities can afford them once every 6 months, the current resources would need to be doubled. If there were other variables contributing to deforestation other than awareness campaigns (which is likely) and there were no synergies between the different determinants, the total gap would be the addition of each of the individual gaps.

Source: ESCWA.

Cost: The concept of “cost” has been used in many different ways, which unfortunately tends to generate confusion.

- By definition, the term “cost” normally refers to expenditure of money, time or labor, necessary for the attainment of an action. In the most basic sense “cost” is used to reflect expenditure, thus being used as a synonymous for “outlay”.
- It can also be used instead of “requirements” – in such case, the notion of “upfront cost” would be more appropriate.
- It can also be used to express the net difference between expenditures and income, reflecting “net cost” or “net benefit”.
- Costs can also refer to the loss in welfare or production that is implied by a course of action, compared to a baseline. Such costs can be expressed at some point in the future (e.g. in 2050) or over a period.

Table A1 below gives examples of how the term “cost” has been used in recent work on financing for development recently

Table A1: Common uses of the term “cost” in development-related publications

Use of term	Notion
“Cost” of MDGs	Upfront cost or outlay, investment need
Cost of climate mitigation	Loss of welfare resulting from mitigation actions to reach a certain target, as compared to a baseline situation in the future
Cost of inaction	Loss in welfare in the future caused by doing nothing, compared to a counterfactual situation where action of some kind is taken
Opportunity cost	Value of the best alternative forgone, in a situation in which a choice needs to be made between several mutually exclusive alternatives given limited resources.

Source: Authors’ elaboration.

Costs can be instantaneous; or they can refer to multiple time periods -- through basic summations over time intervals, to summations discounted for inflation, to intertemporal discounting as practiced by economists and engineers.

Net present value and returns: In an intertemporal context, actions or projects can often be translated into a series of cash flows (positive or negative). The calculation of costs or benefits from a project uses the discounted sum of cash flows to calculate the “net present value” (NPV) of a project, as well as various forms of rates of return on the project – these variables in turn are used to determine whether a project is worth undertaking.

(Investment) requirements: the concept of requirements refers to the resources needed to achieve a specific development path. An example is investment requirements in infrastructure, or in specific technologies. Estimates for requirements can be obtained through various methods, from back-of-the-envelope calculations to direct output from optimization models, for example in some integrated energy-economy models. A number of recent scenario exercises or related publications have taken up this approach.

In comparing estimates of costs and investment requirements, it is important to distinguish incremental investment from total investment. The former refers to amounts of investment over those estimated for a baseline scenario, whereas the latter refer to total investment needed under a counterfactual scenario. Incremental investment can be positive or negative. Its composition in terms of areas or technologies can differ substantially from that of investment under the baseline scenario. It is also important to differentiate between initial investment costs (e.g. for establishment of protected areas) and recurrent costs (e.g. annual costs of management, monitoring...).

Box A2: Comparing costs for different scenarios: the case of renewable energy

Specific investment costs of renewable energy sources are often still higher than those of other energy supply technologies. In order to assess the additional costs arising from using renewable energy sources, two effects must be taken into account. First, investments in renewable energy sources reduce investment needs for other technologies. Second, fossil fuel costs and operation and maintenance costs will be reduced as well. As a consequence, investment needs do not indicate the overall costs faced by societies when increasing the share of renewable energy. In order to calculate total net costs, avoided costs from replaced technologies (compared to a baseline) have to be considered (IEA, 2010a). This can be done on the basis of "levelized costs", which integrate different costs components over the lifetime of investments across technologies. Depending on how cost parameters evolve over time, overall net costs could turn out to be positive or negative.

For example, in the BLUE Map scenario designed by the International Energy Agency, the application of different technologies to deliver a 50% reduction in CO2 emissions by 2050 compared to 2005 requires an additional investment of US$42 trillion. In the same time period, undiscounted fuel cost savings are estimated at US$102 trillion. Even at a 10% discount rate, the fuels savings outweigh the additional incremental investment needs, resulting in net savings for the scenario compared to the baseline.

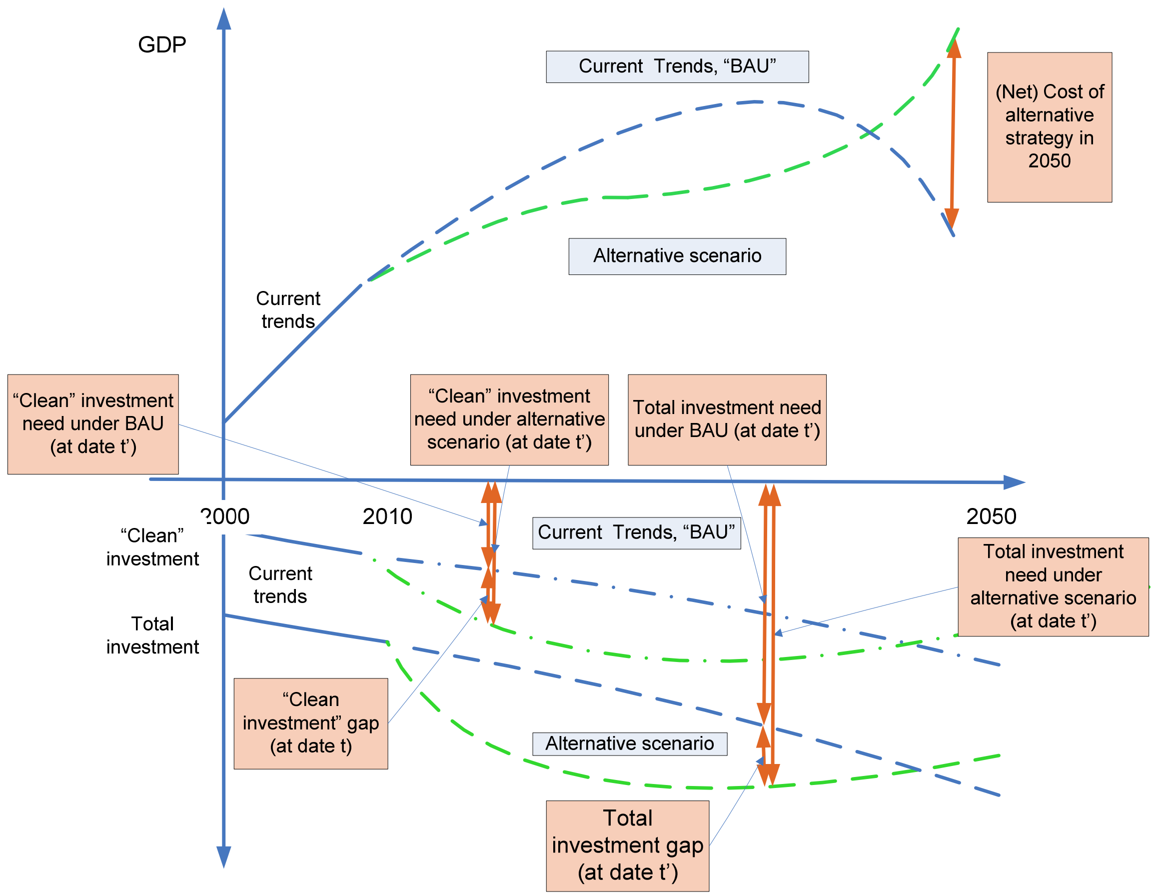
Source: Fideshik et al., 2010.

Financing needs: The notion of financing is broader than that of investment requirements, as it also encompasses qualitative dimensions such as the type of financing that is required (e.g. equity versus debt); the type of instruments and conduits that are used to provide financing (e.g. public grants or loans, bank loans, loan guarantees, corporate bonds, credit facility, fiscal incentives, etc.); and even the capacity-building needs associated with the provision of finance in specific sectors or sub-sectors.

Figure A.1 below illustrates some of the concepts, in a dynamic setting. This type of figure would be relevant to many integrated scenarios of the type run for the IPCC or for integrated sustainable development models. The figure presents two development paths, in terms of evolution through time of GDP and investment requirements. The latter distinguishes between total investment requirements and investments in "clean" sectors. The first, in blue, is the business-as-usual (BAU) path. The green line is an alternative path. These (fictitious) trajectories could be the output of a modelling exercise, for example a climate model. Initially GDP on the green path is below GDP for BAU but catches up and eventually overtakes BAU. Investment requirements are initially higher in the green path, mostly due to investment requirement in "clean" sectors. Eventually, investment requirements are lower for the green path. The "cost" of the alternative path can be measured, relative to the baseline (BAU), as the difference in GDP at any point in time (instantaneous loss/gain of welfare), as shown in the figure; or it can be measured as a weighted (discounted) average over a period, for example from 2010 to 2050.[13]

[13] The form of the BAU curve represented here is not typical of BAU assumptions used in scenario models. See sub-section 2.4.2 for a discussion.

Figure A.1: illustration of some of the definitions in a dynamic context



Source: Author’s elaboration.

Annex 2: Assessing financing needs for sustainable development: Methods used and caveats.

A.2.1. Estimates of costs and investment requirements: main methodologies used

There is a growing literature of cost estimates for achieving global goals, from MDGs to climate-related targets to broader sets of goals. This section of the note focuses on the main methodologies used to obtain estimates, and discusses the potential and limitations of each. At the risk of oversimplification, one may classify the tools or analysis used into six broad categories, with some overlap:[14]

- "Back of the envelope" calculations;
- Descriptive econometric models;
- Computable General Equilibrium (CGE) models;
- Growth Models;
- Engineering systems models; and
- Integrated Assessment Models.

A..2.1.1. "Back of the envelope" calculations

The use of the term "back-of-the-envelope" here simply denotes calculations that are based on data not explicitly linked with a structural model. Many sectoral estimates found in the applied literature are of this kind. The method used is to cost specific actions that are deemed necessary to deliver one goal. Often this is done by multiplying the target population of the action by unit costs found in the literature. For example, when estimating required resources for achieving universal education, Delamonica *et al.* (2001) simply multiplied expenditure per pupil by the projected school age population in 2015 for each country.[15] Some MDGs studies specify measures to achieve the different goals and add up the estimated costs of implementing these measures to obtain an overall cost of achieving the MDGs. Other examples include estimates of costs of climate change adaptation obtained by applying a "climate markup" to investment requirements estimated in various sectors (e.g. IPCC, 2007), as well as the financial needs assessment for the implementation of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets (see section 3.8.1 below).

This approach has evident merits such as simplicity and transparency. It also provides the opportunity to select strategic priority activities that would help achieve an objective in a cost effective way. However, it also has drawbacks. Estimates obtained in this way are sensitive to the cost assumptions used, as well as to the degree of detail with which actions to achieve specific goals are modeled. This approach may also lead to ignoring the synergies and trade-offs among related goals, although the appropriate clustering of activities selected for costing can contribute to mitigate this issue.

A.2.1.2. Descriptive econometric models

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[14] Other approaches exist as well. Non-conventional models have also been used to develop sustainable development scenarios. Among many examples, systems modelling approaches have been used for the influential Limits to Growth (Meadows and Meadows, 1972, updated in 2010). The LowGrowth model developed by P. Victor (2009) has been used to model low or no-growth scenarios in Canada. The extent to which these models can provide cost or investment requirement estimates varies.

[15] Obtaining accurate unit costs at the country level is a common difficulty in these exercises (Heuty, 2009).

Descriptive (as opposed to structural) econometric models have been used to estimate investment needs for infrastructure and in other sectors. These models are based on regressions linking investment in specific sectors, or equipment rates for certain services or technologies, to other variables to which they are correlated, often macro-economic averages observed at a country levels. Assumptions in terms of the latter (for example, in terms of desired GDP growth or target GDP per capita at a certain date) are used to predict equipment or investment levels that would correspond to those. Different model structures exist (e.g. cross-section, time series, panel). Depending on model specification, investment needs are obtained either directly from the model or computed ex post.

A.2.1.3. Computable General Equilibrium (CGE) models

Computable General Equilibrium (CGE) models are commonly used tools for quantifying the costs and benefits of policy. The models can be used to simulate and analyze policy changes and estimate economy-wide impacts captured in a multi-sectoral model. One group of CGE model applications were practically implemented with the focus of modeling the joint production of the goals at the country level for MDG costing estimates (Reddy and Heuty, 2005, 2006). For instance, the World Bank's MAMS model provides a general equilibrium framework for countries to simulate the effect of improvements in one MDG on progress in others (Bourguignon *et al.*, 2008).

CGE models can, in theory, provide insights into changes for which there is no historical experience. The parameters of production and utility functions of the models come from exogenous empirical estimation or "guesses" or from the model calibration process. These "best guess" values add uncertainty into the model. Moreover, the standard CGE approach assumes that there are not and cannot be no-regret options – for example in the case of climate change, opportunities to reduce emissions at zero or negative net cost. In other words, using the CGE approach, mitigation actions are automatically associated with economic costs. This does not reflect the empirical evidence that many mitigation actions would pay off by themselves, as reflected in the work of the IPCC and other reports such as the McKinsey cost abatement curve (2009). This biases results and recommendations derived from these models against taking mitigation action.[16] There are other technical constrains and data limitations to most CGE models, such as difficulty in integrating natural resource sectors and difficulty to account for informal labor markets.

A.2.1.4. Growth models

Growth models have been used to estimate the costs of MDGs and investment requirements for infrastructure, inter alia. One of the first MDG cost estimates was prepared by Devarajan *et al*. (2002) at the World Bank using a growth model (see Annex). The authors estimated the average rate of growth required to reach a poverty reduction goal. Poverty is linked to growth through ad hoc assumptions regarding how the distribution of income reacts to GDP growth. Estimates from such models rely heavily on the assumptions made regarding the links between the variables of interest and GDP growth, as well as (for poverty) how the poor share the benefits from growth. Many sub-types of growth models (such as Balance of Payments Constrained Growth) have been used to estimate financing gaps.

A.2.1.5. Engineering systems models

These models focus on detailed representation of individual sectors (e.g. energy, water), including the various technologies and their cost parameters. This class of models includes MESSAGE, MARKAL, and TIMER, which are core components of the integrated models used by energy modeling institutions.

[16] See Stanton and Ackerman (2009) for a critique of the use of CGE models in modeling impacts of climate policy.

They are often coupled with optimization, partial equilibrium or CGE routines allowing for the calculation of investment requirements under different scenarios as outputs of these models

A.2.1.6. Integrated assessment models

Integrated assessment models (IAMs) provide an analytical framework that can integrate information from a wide range of disciplines in a consistent manner. They are widely used by the climate change community, as well as by modelers concerned with integrated sustainable development scenarios covering areas such as energy systems, water, and agriculture and food (see e.g. Akimoto et al., 2012). One can distinguish two types of integrated assessment models:

- Several sectoral models of the engineering systems class, coupled with soft links in order to integrate feedback across them;
- System dynamics models, which focus on the links and feedbacks between sectors and usually do not include detailed internal description of the sectors.

Many estimates of the economics of climate change are derived from global integrated assessment models, which provide aggregated estimates, assessing costs in a single iterative framework. For example, DICE is a welfare maximization model coupled to a simple carbon cycle model (Nordhaus, 2008). Various types of integrated assessment models exist, which differ in terms of number of assumptions required to provide results (see Stanton and Ackerman, 2009). These assumptions, which are often "hidden" in the technicalities of the models, nonetheless have important bearings on the interpretation of the results that the models provide.[17]

Integrated models covering many sectors have been used by institutes such as PBL in the Netherlands, IIASA in Austria, SEI in Sweden, RITE in Japan and many others to model the economic-ecologic system and monitor a broad range of social, economic and environmental indicators, and assess the feasibility of various sets of goals related to sustainable development. For a simple overview of what these models can do and have done, see UNDESA (2011, 2012).

The way investment requirements are calculated in integrated models varies. Some models obtain them directly as a result of built-in optimization model. Others use ex post allocation techniques to determine investment in various sectors. Still others combine both techniques with "back of the envelope" calculations, especially when addressing investment needs for sectors that are not part of the core model.

Sustainable development scenarios produced for Rio+20 by various research groups have explored a broad range of sustainability goals. Most of those show a clear relationship to major international development and sustainability goals that are either agreed or have been under discussion. They are also grounded in (subsets of) existing mainstream scientific sets of goals, but clearly leave out elements of wider sustainable development perspectives that typically include community or society aspects, such as peace or social capital. Essentially, by sticking firmly to assumptions that are considered plausible and reasonable today, these mainstream scenarios explore what could be achieved by pushing technology to the utmost, supposing we can overcome socio-economic and political constraints, including those related to finance.

Modellers producing estimates of costs or investment requirements usually do not choose exactly the same goals and targets for their scenarios. They also tend to use globally agreed targets partially or selectively. This is illustrated by a review of integrated sustainable development scenarios produced for

[17] The main concerns about climate IAMs as a whole are on assumptions made regarding the shape and scale of future damages, employment and trade, and the importance of future generations' well-being (see Stanton and Ackerman, 2009).

Rio+20. As Table A2 exemplifies, cases where different models choose the same targets as objectives for scenarios constitutes the exception rather than the norm (Roehrl, 2013).

Table A2: Goals and targets in sustainable development scenarios for Rio+20

Vision		Theme	Types of goals, targets, and outcomes	IIASA-GEA	PBL	SEI	OECD	RITE-ALPS	FEEM	GSG
To develop	People	Poverty	Eradicate hunger by 2050		X					X
			Eliminate poverty by 2050			X				
		Access	Universal access to improved water source and basic sanitation by 2050		X		X			
			Universal access to electricity and modern cooking fuels by 2030 {or 2050}	X	X	{X}				
		Health & education	Decreased impact of environmental factors on DALY		X					
			Universal primary education by 2015						X	
	Economy	Income	GDP per capita > US$10,000 PPP in all regions by 2050			X				
			Income convergence; catch-up of Africa by 2050						X	
		Resources	Primary energy use less than 70GJ per capita by 2050						X	
			Primary energy use per capita is only 13% higher in 2050 than in 2010, and 48% higher in 2100					X		
			Use of renewables increase by 3.1 times from 2010 to 2050					X		
			Water demand increases from 3,560 km³ in 2000 to only 4,140 km³ in 2050				X			
		Security	Limit energy trade, increase diversity and resilience of energy supply by 2050	X						
			Population weighted average of energy security index increases only by 2.3					X		
To sustain	Life support	Resources	Limit the increase in the number of people under severe water stress to an additional +2 bln {or +1.4 bln) from 2000, reaching 3.7 bln {or 3.1bln} in 2050				X	{X}		
			People under severe water stress <2 bln until 2050 {or 2.9 billion in 2100}					{X}		X
			Reduce number of people living in water scarce areas vs. trend scenario		X					
			Reduce the area for energy crop production to almost zero by 2020. From 2010 to 2050, limit increase in cropland area for food production to +15%, and reduce the irrigated area for food production by 5%					X		
			Cumulative fossil fuel use limited to <520 Gtoe from 2010 to 2050					X		
			Slow and later reverse deforestation and land degradation							X
			Slow overfishing and later restore fish stocks							X
		Air pollution	Keep PM2.5 concentration below 35 µg m³ by 2030		X					
			Reduce NO_x, SO_2 and black carbon emission by 25% vs. baseline by 2050				X			
			Reduce SO_2 by 42% and black carbon by 21% by 2050 vs. 2010					X		
			Reduce premature deaths due to air pollution by 50% by 2030	X						
	Nature	Climate change	Limit global average temperature change to 2°C [or 2.8°C] above pre-industrial levels with a likelihood of >50% {or 60%} by 2100	X	X	{X}	X	[X]		X
			Atmospheric GHG concentration stabilization below 450 ppm [or 350ppmv] {or 550ppmv} CO_2-eq. by 2100		X				{X}	[X]
			Limit ocean acidification to keep aragonite stable, with pH=8.0 in 2150					X		
		Biodiversity	By 2020: Prevent extinction of known threatened species and improve situation of those in most decline; halve the rate of biodiversity loss; halve the rate of loss of natural habitats and reduce degradation and fragmentation by 2020; conserve at least 17% of terrestrial and inland water. By 2050: stabilize biodiversity at the 2020/2030 level		X					
			CBD Aichi protected area targets of 17% of terrestrial and inland water areas and 10% of coastal and marine areas by 2020		X		X			
		Phosphorus and nitrogen cycles	Phosphorus removal in wastewater treatment increases from 0.7 Mt in 2000, 1.7 Mt in 2030, to 3.3 Mt in 2050				X			
			Reduce Nitrogen and Phosphorus use where possible, but without harming the ability of the agricultural system to meet the hunger target		X					

Sources: IIASA-GEA (Riahi et al., 2012); PBL (van Vuuren et al., 2012) ; SEI (Nilsson et al., 2012), OECD (2012) ; RITE-ALPS (Akimoto et al., 2012) ; FEEM (2011) ; GSG (Raskin et al., 2010).

Note: Brackets and parentheses denote alternative values for targets or dates, as indicated in the list of goals, targets and outcomes.

Source: UNDESA, 2012.

A.2.2. Comparing estimates: main conceptual challenges

One of the reasons for calculating "needs" is, at least in theory, to be able to obtain some estimate of total needs across a society or an economy to deliver a set of specific goals. There are many challenges to this aggregation step, however. Those challenges can be grouped under three broad categories: (1) data issues; (2) varying scope; (3) choice of the baseline; (4) choice of goals and targets; (5) inconsistency; (6) non additivity; and (7) differing time scales.

Data issues

Availability of basic data conditions the feasibility and affects the precision of estimates, whatever methodology is used. It also restricts options in terms of methodology choices. Other caveats are related to international data comparison. For example, the choice of currency and the way to aggregate costs across countries impacts estimates.

Varying scope

The issue of varying scope manifests itself at different levels. Specific models are focused on sectors or activities, and the definition of sectors can encompass different activities. For example in the energy sector, some models focus on electricity production, others on broader definitions of the energy system. The types of technologies considered by energy models differ. The same may apply to sectors such as agriculture. Numerical estimates from models operating on different perimeters are therefore not directly comparable.

Many costing exercises proceed by "bottom up" aggregation of costs or requirements that are computed for each goal or sub-goal considered. Those are broken down into actions or activities that are costed (see above section A.2.1.1). Different evaluation exercises will focus on different set of actions, thus resulting in different estimates for the goal as a whole, notwithstanding differences in the costing methods. The geographical scope of models and estimates can also vary.

Importantly, due to feedbacks in the economic-ecological system, success in one sector (as measured by the achievement of specific goals or targets) is in many cases dependent on actions in other sectors. In addition, the cost of reaching a specific goal is hard to isolate – there are synergies and trade-offs between goals, resulting in co-benefits or adverse impacts across policies and actions.

For example, loss of biodiversity is impacted by many outside factors that put pressure on biodiversity, such as agriculture, deforestation, and climate change, all of which in turn are impacted by consumption patterns. This is why the Aichi targets include targets for forests, as well as targets for sustainable consumption and production and other general macro-economic measures. This illustrates the fact that a chosen set of activities deemed necessary in a sector may or may not be sufficient to achieve given targets; and therefore, investment requirements for a sector derived from costing such activities embody implicit assumptions on what happens in other sectors. Caution should be exercised when interpreting such estimates. This interdependence also results in double counting when adding estimates from different sectors.

Choice of the baseline

As illustrated above, estimating additional investment requirements under any scenario requires the choice of a baseline. This choice has a critical importance on the "needs" or requirements that will be estimated. For example, the choice of future GDP growth rate in climate mitigation scenario will impact estimations of future energy demand and emissions. Similarly, the choices made regarding policies and technological change under business as usual scenarios will impact the magnitude of the needs in e.g. clean energy infrastructure to keep CO_2 concentrations under a given threshold in the future. The more conservative the baseline is in terms of mitigation policies, the higher estimated additional investment requirements will be. Because no one knows what the future will be, the choice of the "most likely" baseline is difficult; yet, it has an important impact on estimates of needs and investment requirements.

An example of the latter case is that of "inconsistent baselines". Most of the scenario exercises for climate start with an assumption of everlasting economic growth under BAU. This is of course inconsistent with a message of climate and environmental science that beyond some thresholds, collapse of ecosystems would occur and eventually lead to decrease in GDP (UNDESA, 2011). Such baselines are likely to result in overestimation of costs of alternative (sustainable) scenarios.

Choice of goals and targets

Modellers producing estimates of costs or investment requirements usually do not choose exactly the goals or same targets in their scenarios. Even when models focus on the same objectives, such as a target level for CO_2 concentration at the end of the 21st century as many climate models do, the dynamics of specific models result in wide variations in paths and outcomes which have direct implications in terms of investment requirements. Figure A.2, taken form a recent IPCC report, illustrates this variability on the estimated energy supply stemming from 164 scenarios produced by mainstream climate models. Variability is evident even for scenarios focusing on the same climate objectives (IPCC, 2010).

Figure A.2: Historic global primary energy supply and projections from 164 long-term scenarios

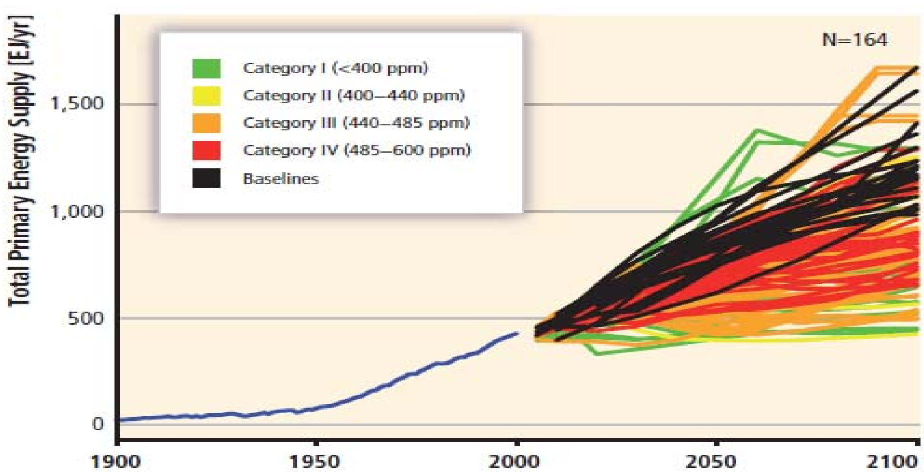

Figure 10.3 | Historic global total primary energy supply (direct equivalent) and projections from 164 long-term scenarios. Colour coding is based on categories of atmospheric CO_2 concentration level in 2100 (Fisher et al., 2007), with historic data from Grubler (2008). Figure and data adapted from Krey and Clarke (2011), modified to include two additional scenarios.

Source: Fideshick et al., 2010.

Inconsistency

Cost estimates obtained from different models generally cannot be added. This is because different models use different specifications of the dynamics underlying the economic and environmental systems. Two models would give different estimates of the costs of achieving the same target. This is a very practical problem, given that there exists no single integrated model that covers all the areas relevant to comprehensive sets of sustainable development objectives (Roehrl, 2013). Scenario exercises covering a broad range of areas often use coupled models to derive estimate; ultimately, one should bear in mind that costs or investment requirements derived this way may not be fully consistent.

More generally, methods used also differ because of data availability, reflecting limitations to usable data in many sectors and countries. They also differ in terms of assumptions, as well as in the degree of detail to which specific policies are modeled. This can affect estimated needs several-fold. As an example, the costs of universal access to clean cooking fuels estimated recently by two leading institutions in the field, IEA and IAASA, varies from US$ 4.4 billon to US$ 71 billion per year.[18]

Non-additivity

The cost or implied investment requirement of reaching a set of goals is not equal to the sum of the costs of reaching the goals separately. First, any two goals or targets may not be compatible. Broader sets of goals may not be all achievable. Thus, *feasibility* of a set of goals is a critical dimension, even before costs can be compared. Second, when the goals are achievable simultaneously, the cost to achieve all of them can be higher or lower than the sum of the costs to achieve individual goals, depending on the synergies and trade-offs that exist between these goals and the related actions chosen to deliver them, given the dynamics of the economy-society-ecology system.

In theory, only integrated models can say something about the costs of achieving multiple goals simultaneously, because they are able to model synergies and trade-offs across clusters or areas. However, because different models are based on different assumptions, they give different results. This results in differing assessments of trade-offs and synergies among sectors that have been found in the recent literature on integrated sustainable development scenarios (Roehrl, 2013).

A last but important cause of non-additivity is caused by overlapping scopes, activities and actions included under in estimates of investment requirements in different areas. Some activities or policies impact several outcomes of interests. For example, actions to provide universal electricity access can have positive impacts on children education or income generation capacity of households. Conversely, the actions needed to achieve goals and target for a specific sector often encompass actions in other sectors. For example, in order to preserve biodiversity, actions are needed in terms of forest management, ocean management, and broader macro-economic policies (see section 2.4.1 above). Therefore, adding estimates from different sectors based on partially overlapping activities or actions often results in double counting. The clearest example is that of climate change mitigation. Actions to mitigate climate change impact a broad range of sectors (notably energy, transport, forestry, and agriculture). Hence, investment requirements to achieve specific climate mitigation targets will often overlap with investment requirements derived from goals and targets in those sectors. Similarly, investment needs estimates for infrastructure often include the energy sector, thus creating double counting between the two.

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[18] IIASA's higher estimates for modern cooking solutions are based on the assumption that fuel subsidies of around 50% for LPG and microfinance at an interest rate of 15% will be necessary to cover investments in improved cookstoves (World Bank and IEA, 2013).

Differing time scales

A last caveat to keep in mind when comparing estimates is the differing time scale of various goals and targets. For example, universal access to electricity could likely be achieved in a decade from a purely technical point of view. On the other hand, the transformation of energy systems to drastically limit greenhouse gas emissions, even if it were given top priority, would take at least several decades. Therefore, the time dimension needs to be kept in mind when comparing annual estimates of investment requirements.[19]

[19] Related to the time dimension, the choice of the discount factor is also important.