Global Costs of Achieving the Aichi Biodiversity Targets

A Scoping Assessment of Anticipated Costs of Achieving Targets 5, 8, and 14

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Executive Summary

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ES.1.0 Background

In 2010 parties to the Convention on Biological Diversity (CBD) adopted the Strategic Plan for Biodiversity 2011 – 2020 with the purpose of stimulating a diverse array of activities by governments, NGOs, business leaders, and other stakeholders to halt the loss of biological diversity. In recognition of the critical importance of biological diversity for livelihoods, wellbeing, health and the genetic foundations of modern agriculture the parties agreed to an ambitious set of 20 targets – many of them time bound and quantitative – for slowing, halting, and reversing biological diversity loss associated with degradation of aquatic and terrestrial ecosystems throughout the world. Collectively, these are known as the Aichi Biodiversity Targets. The costs and benefits of achieving these targets are of keen interest to policy makers as they begin the process of implementing programs of work and on-the-ground activities. Choosing the most cost effective means of implementation is critical given the overall political and economic environment of fiscal austerity facing governments in both developed and developing countries.

In May of 2012, the U.K. Department for Environment and Rural Affairs (Defra) entered into an agreement with Center for Sustainable Economy (CSE) to develop a rough order of magnitude estimate (ROM) of the resource requirements of meeting three of the Aichi Targets: 5 (wetland component), 8 (pollution), and 14 (ecosystems). Our objectives are threefold: (1) to identify cost considerations associated with meeting the targets, including activities that may result in a cost savings (negative cost); (2) to lay the groundwork for a more robust assessment, and (3) to produce a first cut ROM range based on existing published information.[1] For each target, we first refine understanding of what it will take to achieve it. We then identify key activities that are likely to help achieve the target in a cost effective manner. Subsequently, we develop portfolios of activities that represent the least cost and highest cost approaches, and then report global ROM estimates for each based on the best available information publically available at this time. We conclude the analysis of each target with a discussion of both market and non-market economic benefits associated with implementation activities and a roadmap for more robust cost assessments.

ES.2.0 Aichi Target 5 – Wetland Component

"By 2020, the rate of loss of [wetlands] is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced."

Preliminary ROM Global Cost Assessment ($2012 USD):

- USD $46.27 – $108.73 billion annually.

ES.2.1 - <u>Refinement</u>

Target 5 actually addresses all natural habitats, including forests. The CSE analysis, however, is limited to the wetland component. Thus the goal is to develop ROM estimates of achieving a reduction in the rate of wetland loss of at least 50% by 2020, 100% where feasible, and in ways that also reduce degradation and fragmentation. For purpose of this costing exercise, we assume that achieving a 50% reduction in the overall rate of loss may mean a minimal reduction in some areas and perhaps as high as 100% in others. We also assume that activities (identified below) to achieve the target can be implemented in a manner

[1] By necessity, costing the Aichi targets involves a substantial degree of uncertainty that permeates every data point along the way from estimates of baseline conditions and trends to costs of implementation across different countries to effectiveness. As such, we believe using ROM as a standard for this preliminary scoping exercise is best practice.

that also reduces degradation and fragmentation. As such, we focus our cost analysis on the 50% reduction component.

An obvious point of departure for the costing exercise is to calculate the baseline rate of loss for major wetland communities so that Target 5 can be translated into hectares conserved (i.e. loss prevented) per year and total over the 2012 – 2020 period. Ideally, baseline rates of loss would tier to the 47 marine and inland wetland types identified by the Ramsar Convention classification system for wetland types as approved by Recommendation 4.7 and amended by Resolution VI.5 of the Conference of the Contracting Parties.[2] While estimates of the global rate of loss for each Ramsar wetland type have not been generated, there are a handful of global assessments available that can serve as the starting point for our analysis.

The most rigorous of these assessments developed data on current extent and annual rate of loss either in percentage or absolute terms for six major wetland categories including mangroves, seagrass, salt marsh, peatlands, freshwater wetlands and delta plains. In addition, we incorporated figures published in the 2005 Millennium Ecosystem Assessment to account for wetlands not covered in these other categories. After adjusting for losses incurred subsequent to the assessment date based on rates of loss quantified in each of these assessments and eliminating overlap, we produced an estimate of the current rate of loss at 1% and 2% per year for seven wetland categories. Table ES-1 synthesizes the results of this analysis. Three key conclusions emerge:

- The global rate of loss of all wetlands is probably in the order of 11.65 to 23.30 million hectares per year. At a rate of 1.5% each year, this translates into an annual loss of 17.47 million hectares.
- This implies a conservation target of 5.82 to 11.50 million hectares per year to achieve the goal of halving the rate of loss. At a loss rate of 1.5% the annual target would be 8.74 million hectares.
- If that conservation target were achieved in 2012 and sustained, it would result in protection of nearly 79 million hectares that would otherwise be lost by 2020.

Table ES-1:
Rough Estimate of Wetland Conservation Needed to Achieve Target 5

Wetland type	Global extent 2012 (ha)	Rate of loss @ 1.5 % (ha/yr)	Conservation target (ha/yr)	2020 Conservation target (ha)
Mangroves	14,720,762	220,811	110,406	993,651
Seagrass	17,434,500	261,518	130,759	1,176,829
Salt Marsh	39,200,000	588,000	294,000	2,646,000
Peatlands	384,800,000	5,772,000	2,886,000	25,974,000
Other freshwater wetlands	97,855,164	1,467,827	733,914	6,605,224
Major delta plains	56,640,494	849,607	424,804	3,823,233
All other wetlands	554,250,030	8,313,750	4,156,875	37,411,877
Total	1,113,600,000	17,473,514	8,736,757	78,630,814

ES.2.2 – Key activities to achieve the target

To identify key activities that could be undertaken to achieve this conservation target, we first considered major drivers of loss, degradation, and fragmentation reported in the literature. These are relatively well understood, and include coastal development, agricultural conversion, water diversions, channelization, dams, roads, invasive species and climate induced sea level rise. Given this, our first criteria for selecting activities to reduce the rate of loss is to focus on those which have immediate impacts on the ground in addressing these drivers of change, excluding climate, which we presume should not be addressed via

[2] For a complete description of the Ramsar wetland types, see: http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-26-76%5E21235_4000_0__.

Aichi since it is being negotiated separately under other international processes. Our second criteria was to focus on activities with zero or negative costs first, then activities that are relatively low cost but high impact, and finally those that come with a fairly hefty price tag and relatively lesser impact only if necessary. Our third criterion was to focus on activities that can simultaneously help achieve other targets. With these criteria in mind and after review of activities identified in national biodiversity action plans and other sources, we developed a list of activities to incorporate into the cost exercise. These include:

- Removing harmful subsidies and other forms of public support for non-essential infrastructure that impinges on natural wetland habitats.
- Implementing "no net loss" standards and associated wetland banking systems similar to effective programs managed in the United States and European Union.
- Providing cost share assistance for agriculture and forestry best management practices to protect wetland communities affected by these land uses.
- Improving national wetland inventory, monitoring and enforcement capabilities.
- Increasing the amount of wetlands of international importance designated under the Ramsar Convention or otherwise protected in national wildlife refuges, parks, or conservation units.

ES.2.3 – Preliminary cost assessment

To develop a ROM estimate of achieving Target 5 by implementing these activities globally, we first refined the activity list into discrete means of implementation and then identified major cost considerations for each. With respect to harmful subsidies and other forms of public support, public expenditures on new dam construction and water infrastructure were identified as the most promising sources of cost savings with beneficial impacts on wetlands conservation. Combining available data on the number of new dams with high impact and for which alternatives are available, global expenditures on water infrastructure, and estimates of cost savings associated with investing in green rather than "gray" infrastructure we developed a conservative estimate of 10% ($11.40 billion) of the amount of global spending on water infrastructure ($114 billion annually) that could be canceled to reduce wetland loss without significant effects on economic development.

With respect to no net loss programs, wetland credit purchases and public agency management of wetland mitigation programs were identified as the primary cost factors. With respect to cost share assistance, we assumed that payments for ecosystem services (PES) would be the primary mechanism, which is a form of public acquisition of development rights. Direct acquisition at fair market value was assumed to be the major cost consideration for wetlands formally designated under Ramsar or otherwise added to national protected area systems. For each of these, we developed a set of ROM unit cost estimates based on a review of available data sources and translation of that data into common units. Results are presented in Table ES-2.

Table ES-2:
Unit Cost Estimate for Select Target 5 Activities

Activity	Low ($/ha)	High ($/ha)
Wetland acquisition (mean)	$631	$5,145
Fair market value	$1,000	$10,000
Payments for ecosystem services	$262	$289
Protected area management	$5	$50
Wetland credit prices	$3,000	$30,000
Wetland mitigation management	$150	$1,500

Based on these unit cost ranges, we then developed three cost scenarios that reflect our best guess as to the upper and lower limits of the annual cost range for achieving Target 5. The three scenarios were based on different proportions of the annual target conserved by private entities by way of wetland credit purchases or public entities by way of land or development right acquisition (PES) and associated management costs. In Scenario 1, we assumed that private entities would bear responsibility of conserving 75% of the annual conservation target through wetland banking programs that require fully functional offsets of each hectare of wetland developed. The remaining 25% of the annual target would be conserved through public acquisition programs that are evenly split between fee simple purchases at fair market value and payments for ecosystem services negotiated through either conservation easements or agricultural and forestry best management practice contracts.

In Scenario 2, the responsibility for attaining the annual target is evenly split between these public and private options, and in Scenario 3, public agencies would bear 75% of the responsibility. Unit costs for each scenario were assumed to represent mean values at the center of each of the ranges discussed in Table ES-2. In each scenario, we held negative costs associated with reduced public infrastructure spending constant at $11.40 billion annually, and the area protected through such cost savings measures is conservatively set at zero since we have no reliable data as yet to link such savings to reductions in wetland loss. The results are provided in Table ES-3, and suggest a range of $46.27 - $108.73 billion annually, and can be considered a reasonable estimate of the upper end of the range of achieving Target 5.

Table ES-3:
Target 5 Scenarios and Rough Order of Magnitude Global Cost Estimates

Wetland type	Acquisition costs ($billion/yr)	Management costs ($billion/yr)	Private costs ($billion/yr)	Cost savings ($billion/yr)	Net costs ($billion/yr)
Scenario 1: *Minimize public costs*	$6.31	$5.71	$108.11	$11.40	$108.73
Scenario 2: *Equal distribution*	$12.62	$4.20	$72.08	$11.40	$77.50
Scenario 3: *Minimize private costs*	$18.92	$2.70	$36.04	$11.40	$46.27

As Table ES-3 indicates, achieving the annual Target 5 wetland loss reduction target primarily through wetland banking or other forms of compensatory mitigation by private parties designed to meet a no net loss standard is probably the most expensive approach. In Scenario 3, the annual costs would exceed $108 billion annually and represent an overall unit cost of $12,363 per hectare of which $11,792 can be considered an investment cost and $654 a recurring management cost. The relatively high cost of Scenario 1 makes intuitive sense because the costs of creating new wetlands that are functionally equivalent to those lost is much higher than merely protecting wetlands that exist now. In contrast, Scenario 3 would result in an overall global cost of $46.27 billion annually, or $5,296 per hectare, of which $4,985 can be considered an investment cost and $311 a recurring management expense.

It is important to note that the scenarios presented in Table ES-3 are just three of a large number of scenarios that could be run with the existing data. Unit costs, annual conservation targets, the distribution of those targets between public and private programs, the mix of public programs, and the annual hectares conserved through cost savings measures are all parameters that can be varied to create other scenarios that could provide an even wider range of overall costs. For example, a minimum cost scenario could adopt the lowest unit cost estimates, an annual conservation target based on an assumed rate of loss of 1%, a distribution of 90% or more towards public programs, a significant amount of area conserved through cost savings. In subsequent phases of this research, more robust global cost estimates can be developed by running a larger set of scenarios based on variation of these parameters.

ES.3.0 Aichi Target 8 – Pollution Detrimental to Biodiversity

"By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity."

- USD $140.87 - $399.97 billion annually.

ES.3.1 - Refinement

In order to refine the target, we first conducted a literature review of global pollution and its impacts on biodiversity and found nutrient runoff from agricultural and urban areas, solid waste pollution of the marine environment, and air pollution to be the most frequently cited stressors for biodiversity and ecosystem function. Thus, the goal of our analysis is to determine ROM estimates of reducing these pollution sources to levels not detrimental to ecosystem function and biodiversity. As all countries contribute to pollution to some degree, we focused most of our analysis on biodiversity hot spots.

We then quantified baseline pollution levels and geographic areas of focus. For nutrient pollution, we used the best available spatial data on dead zones and overlaid this with spatial data on biodiversity hot spots. Only coastal dead zones were included in this analysis as mapping was largely not available for freshwater zones. From this data, we targeted 162 coastal eutrophic and hypoxic areas within 46 countries. We then quantified the area of urban and agricultural land and population size upstream from these dead zones to serve as a basis for cost estimates. For marine debris, we compiled global data on the plastic waste stream entering the oceans each year. For air pollution, we assume the majority of pollution comes from cities that have higher counts of vehicles, industrial facilities, and a higher energy demand. We then identified the top ten most heavily polluted cities to see which countries have the biggest impact on biodiversity.

ES.3.2 - Key activities to achieve the target

To determine which activities should be targeted to address these three pollution sources, we conducted a literature review and assessment of what leading countries are doing. We also applied the three criteria set forth in Section 2 to select activities with high impact beginning with those that could be achieved a least cost. From this analysis, and based on available data, we identified the following activities:

- Increase wastewater treatment capacity to cover populations living upstream of dead zones without access to sanitation.
- Reduce nutrient runoff from upstream agricultural operations through the use of best management practices.
- Invest in urban stormwater retrofits for existing impervious surface areas.
- Develop clean-up programs including mechanical cleanup of floating plastic debris and voluntary buy-back programs.
- Invest in converting synthetic plastic production to biodegradable plastic production.
- Install best available technologies for stationary sources of pollution including industries and coal-fired power plants.
- Implement fuel efficiency standards for automobiles.

ES.3.3 – Preliminary cost assessment

Whenever possible, we attempted to gather data from both developing and developed countries and to distinguish between investment and ongoing costs. However, data was severely restricted in most cases to the United States, the European Union, Japan, and Canada. Additionally, global data generally did not distinguish between initial investment and annual cost so for this Phase I analysis we limited our analysis to the latter. Table summarizes baseline and reduction target data. Table summarizes unit cost data for each pollution measure. Table summarizes total cost estimates.

ES.3.3.1 - Marine debris

Plastics are by far the dominant source of marine debris, constituting between 60–70% of total solid waste, or approximately 158 million metric tonnes. Roughly 3.8 to 5.1 million metric tonnes enters the oceans each year. Once in the ocean, 15% of debris floats on the sea surface, 15% remains in the water column, and 70% sinks to the seabed. Estimates place the amount of floating debris at roughly 23.64 million metric tonnes. Ideally, to eliminate detrimental impacts on biodiversity all debris near the surface would be eliminated and all new debris entering the oceans converted to biodegradable plastics. We thus set our conservation targets for these at zero as a maximum attainment value (Table ES-5).

For a marine debris cleanup program, we incorporate a global estimate of $13 billion for a comprehensive global program and divide this amount equally over 2012 - 2020 for an annual cost of just roughly $1.44 billion. An alternate program would consist of a "buy back" program that provides incentives for fishers to engage in clean up activities as part of their normal operations. Costs of achieving clean up in this way would be somewhat higher, roughly $2.22 billion a year. For converting the plastic waste stream into biodegradables we took the estimate of the annual waste stream entering the ocean and multiplied it by the cost differential between synthetic and biodegradable plastic on a per unit basis. We assume no investment costs are needed for the production of biodegradable plastics, only a change in material costs. Unit cost ranges are based on an average of all synthetic and biodegradable plastic types (e.g., LDPE, HDPE, polystyrenes). Table ES-6 suggests a ROM range of $25.59 – $44.46 billion in annual costs to meet marine debris and plastic conversion goals based on these lower and upper bound unit cost estimates.

ES.3.3.2 - Nutrient runoff

In our cost analysis, we focus on the three major sources of nutrient pollution: wastewater, agricultural runoff, and stormwater. Ideally, costs for improving wastewater capacity would be based on knowing the treatment capacity needed for each country. As this information is not easily available for all target countries, we tie our analysis to the Millennium Development Goal (MDG) target for sanitation, which states, "[h]alve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation."

To calculate a ROM to meet this MDG target for our key countries, we first determined the current proportion of the population in each country lacking access to sanitation using the MDG database. We applied this percentage to the total global population living upstream of target dead ones. We then estimated the population size needed to reduce this proportion to half of 1990 levels (65.03 million a year) and then multiplied this by the average cost per person of improved sanitation to meet the MDG target ($6.13 - $9.33). Because other programs are largely meeting the MDG target, we attribute just 10% of the cost of meeting the MDG target to programs designed to achieve the Aichi biodiversity goals. This figure will be refined in the next phase of this analysis once better data on MDG implementation programs can be retrieved. The results suggest that with respect to wastewater, achieving reductions sufficient to maintain downstream biodiversity would cost between $39.84 and $60.67 billion annually.

To determine the cost of reducing nonpoint source pollution from agriculture, we first determined the total upstream area of agricultural land from dead zones. We then calculated an average nutrient load rate for nitrogen (N) and phosphorus (P) from agricultural land using the best available data (largely from the Chesapeake Bay area). This provided us with total N and P loads per year for target countries (Table ES-4). Our next goal was to determine target reduction amounts for N and P. Many countries have national policies in place (e.g., total maximum daily loads) to target reduction amounts. Based on a survey of available data we assume overall long term global reduction goals for N and P of 50% and 45% respectively, half by 2020 (Table ES-4).

To determine the cost of meeting these targets, we determined the average cost per hectare for a suite of agricultural BMPs known to reduce nutrient runoff. These BMPs include nutrient management (fertilizer use reduction), conservation tillage, cover crops, riparian forest buffers, grass buffers, water control structures, and animal waste management (Table ES-5). As it is difficult to determine to what extent each BMP should be implemented, we calculated an average annual cost of implementation on a per tonne basis (Table ES-5) and multiplied this by the reduction target. For purposes of this initial analysis, we assume that measures to reduce nitrogen will have the ancillary impact of also reducing required phosphorous loadings – an assumption borne out in many settings thus far. The results suggest an annual cost of $66.18 to $151.63 billion per year based on lower and upper ends of the unit cost ranges.

With respect to stormwater runoff, we first calculated the urban area upstream of our coastal dead zones and then determined an average N and P runoff rate per hectare from stormwater and urban land using spatial data and evidence from the literature. Given climate variability, annual runoff estimates suffer from an extremely high degree of variation (Table ES-5). From this data we were able to calculate total nutrient runoff from stormwater per year for target countries upstream from oceanic dead zones. To determine target reduction amounts for N and P, we assume that the long term 50% and 45% targets for agriculture also apply to stormwater and that half of this will be achieved by 2020. To determine the cost of meeting these targets, we determined the average cost per kg of stormwater control measures known to reduce nutrient runoff and then applied this average to the required reduction range. The results suggest a range of $3.26 to $137.21 billion annually.

ES.3.3.2 – Air pollution harmful to biodiversity

Air pollution from industrial activities, transportation, and energy production causes or contributes to eutrophication, the acidification of water bodies and soils, reduction in plant photosynthesis, and reduction of reproduction success. The major air pollutants contributing to biodiversity loss include nitrogen oxides, sulfur dioxide, particulate matter, ozone, carbon monoxide, and lead. Cities are by far the largest pollution centers. As a result, we concentrate our cost methodology on reducing pollution for the top ten cities for worst air quality that also overlap with known biodiversity hot spots: Beijing, China, New Delhi, India, Santiago, Chile, Mexico City, Mexico, Ulaanbaatar, Mongolia, Cairo, Egypt, Chongquing, China, Guangzhou, China, Hong Kong, and Kabul, Afghanistan.

As it is difficult to determine the number of industries and air quality controls needed for each country, let alone air quality standards, we base our cost estimates on the average annual costs of meeting state of the art air quality standards as a proportion of country level GDP. We first conducted a literature review to assemble relevant cost data. We retrieved usable data for the United States and Europe. If we assume these countries have some of the stricter guidelines in the world and air quality under these programs generally sufficient to meet biodiversity conservation goals then our cost estimate is based on bringing countries with cities listed in the top ten up to speed. We divided total annual cost estimates for the U.S. and Europe by their 2011 GDP. We averaged these estimates and applied it to the GDP of the above - mentioned countries. As with the MDG target, we then assumed that any programs related to attaining Aichi targets would be incremental to other programs designed to achieve other objectives such as public health or climate, and so we attribute just 10% of costs of implementing clean air measures to Aichi. The results suggest an annual cost of roughly $6 billion.

Table ES-4:
Rough Estimate of Pollution Reduction Needed to Achieve Target 8

Pollution Type	Unit	Global baseline	Conservation Target
Marine Litter			
Synthetic plastic entering global oceans	tonnes/yr	3,840,000 –5,120,000	0
Floating plastic debris currently in oceans	tonnes	23,625,000	0
Nutrient pollution			
Wastewater - population in need of sanitation	people/yr	863,674,293	65,030,949
Agriculture nutrient loading rate (TN)	kg/ha/yr	5.9 – 13.5	1.5 – 3.4
Agriculture nutrient loading rate (TP)	kg/ha/yr	1.5 – 1.6	0.4 – 0.45
Stormwater nutrient loading rate (TN)	kg/ha/yr	1.12 – 47.17	0.29 – 11.79
Stormwater nutrient loading rate (TP)	kg/ha/yr	0.16 – 6.64	0.04 – 1.66
Air pollution harmful to biodiversity	ppm	n/a	Best available technology

Table ES-5:
Unit Costs for Target 8

Pollution Source	Unit	Cost Range
Marine Litter		
Synthetic plastic production	$/tonne	$1,250 – $1,713
Biodegradable plastic production	$/tonne	$8,000 – $9,500
Mechanical cleanup of floating debris	$billion/yr	$1.44
Buy-back program	$billion/yr	$2.22
Nutrient pollution		
Wastewater - cost to meet MDG target	$/person/yr	$6.13 – $9.33
Agricultural BMPs (TN)	$/kg	$26.80
Agricultural BMPs (TP)	$/kg	$863.48
Stormwater controls (TN)	$/kg	$368.87
Stormwater controls (TP)	$/kg	$279.19
Air pollution	$/$GDP	$0.005

Table ES-6:
Target 8 Activities and Rough Order of Magnitude Global Cost Estimates

Activity	Annual Cost ($2012 billions/yr)
Eliminating harmful marine debris	25.59 – 44.46
Improved sanitation (incremental to existing programs)	39.84 – 60.67
Agricultural best management practices	66.18 – 151.63
Stormwater controls	3.26 - 137.21
Reducing harmful air pollution (incremental to existing programs)	6.00
TOTAL	$140.87 - $399.97

Taken together, our preliminary ROM cost estimate for achieving Target 8 falls into the global cost range of $140.87 to $399.97 billion (Table ES-6). As with the global cost estimates for Target 5, there are multiple ways to reconfigure the assumptions inherent to Table ES-6 to generate significantly different estimates – for example, by adjusting assumptions regarding the extent of air and sanitation goals to be met by non-Aichi related programs or by altering the mix of stormwater or agricultural BMPs. So as with

Target 5, an expanded analysis for subsequent phases of this work would be to develop a much richer number of scenarios based on variation of all key parameters.

ES.4.0 Aichi Target 14 – Ecosystem Restoration

ES.4.0 Benefits of Meeting the Targets

ES.5.0 Roadmap to a More Complete Benefit-Cost Analysis