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# An initial estimate of the value of ecosystem services in Bhutan

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ABSTRACT

We estimated the value of ecosystem services in Bhutan using benefit transfer methodology in order to determine an initial assessment of their overall contribution to human well-being . The total estimated value was approximately $15.5 billion/yr (NU760 billion/yr), significantly greater than the gross domestic product (GDP) of $3.5 billion/yr.

We also estimated who benefits from Bhutan's ecosystem services. 53% of the total benefits accrue to people outside Bhutan. 47% of the benefits accrue to people inside the country—15 % at the national level, and 32% at the local level. Based on this and a population of 700,000 we estimated Bhutan's combined per capita annual benefits at $15,400/capita/yr. Of this $5000 is from goods and services captured in GDP and $10,400 is from ecosystem services. This is only a partial estimate that leaves out other sources of benefits to people, including social and cultural values.

This study is the first phase of a larger, multiyear project and ongoing effort in Bhutan. Subsequent phases will apply more sophisticated methods to further elaborate the value of Bhutan's ecosystem services, who benefits from them, how they can best be integrated into national well-being accounting, and how best to manage them.



## 1. Introduction

Bhutan is a small (population approximately 700,000) Himalayan country whose Fourth King declared that the goal of his country's policy was "Gross National Happiness" (GNH) rather than "Gross Domestic Product" (GDP). GNH aims to integrate sustainable and equitable economic development across nine domains: psychological wellbeing, health, education, culture, time use, good governance, community vitality, ecological diversity and resilience, and living standards.

After a very interesting and unique transition to democracy initiated by the Fourth King, Bhutan is now a constitutional monarchy—much like Britain—where the King has mainly ceremonial duties. The first democratically elected Prime Minister, Lyonchoen Jigme Y. Thinley, and the elected government have set up a "Gross National Happiness Commission" (GNHC)the former Planning Commissionto develop the country in accord with GNH principles. The Commission has developed a GNH policy screen based on GNH indicators, measures, and surveys developed by the Centre for Bhutan Studies, Bhutan's primary think-tank .

More than half of Bhutan's land area is under environmental protection (Ministry of Agriculture and Forest, 2012), and national policies include the goal to become the first country to produce only organic food, to be a net carbon dioxide sink in perpetuity, and to have a pedestrian Tuesday, where no cars are allowed in any major city on Tuesdays.

The Bhutanese recognize the need to move beyond GDP due to its well-known limitations as a national welfare measure and policy goal. GDP is the total market value of all final goods and services produced in a country in a given period. But GDP was never intended as a measure of well-being or progress. It is based on current prices, which are not appropriate measures of scarcity, especially of natural and social capital. It also only measures national income or economic activity and only includes those goods and services traded in markets. It also adds all economic activities together, without differentiating between those that enhance well-being and those that reduce from it. An oil spill, for example, increases GDP because of the clean up work required, but it obviously detracts from well-being . More crime, sickness, war, pollution, fires, storms, and pestilence are all potentially positives for GDP because they increase economic activity. GDP also takes no account of how the national income is distributed among the population, ignoring the fact that a dollar's worth of income produces more well-being for a poor person than a rich one.

GDP is precise but not accurate. It is precise because it is replicable; it is inaccurate (as a measure of welfare) because it

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**Table 1**
Ecosystem service values (ranges and means) for 9 land-cover types.

| | Ref | Total area (ha) | Total area (%) | Min value ($US/ha/year) | Max value ($US/ha/year) | Mean value ($US/ha/year) | Min value ($US/year) | Max value ($US/year) | Mean value ($US/year) | Total value (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cropland** | **17** | **309,728** | **8.0** | **$798** | **$2864** | **$1831** | **$224,030,375** | **$887,156,484** | **$567,132,576** | **3.7** |
| Provisioning services | | | | $145 | $181 | $163 | $45,059,914 | $56,045,822 | $50,552,868 | |
| Food | 2 | | | $71 | $106 | $89 | $21,981,621 | $32,967,530 | $27,474,576 | |
| Raw materials | 1 | | | | | $11 | | | $3,296,412 | |
| Water | 1 | | | | | $64 | | | $19,781,880 | |
| Regulating services | | | | $651 | $2649 | $1650 | $201,718,432 | $820,338,334 | $511,028,383 | |
| Air quality | 1 | | | | | $53 | | | $16,482,062 | |
| Biodiversity protection | 2 | | | $76 | $1930 | $1003 | $23,405,209 | $597,718,604 | $310,561,907 | |
| Biological control | 1 | | | | | $28 | | | $8,734,320 | |
| Climate regulation | 1 | | | | | $95 | | | $29,340,795 | |
| Erosion prevention | 2 | | | $51 | $135 | $93 | $15,734,164 | $41,793,874 | $28,764,019 | |
| Pollination | 1 | | | | | $19 | | | $5,822,880 | |
| Soil formation | 2 | | | $155 | $214 | $185 | $48,131,708 | $66,378,506 | $57,255,107 | |
| Water purification | 1 | | | | | $175 | | | $54,067,294 | |
| Cultural services | | | | $1 | $35 | $18 | $330,322 | $10,772,327 | $5,551,325 | |
| Recreation | 2 | | | $1 | $35 | $18 | $330,322 | $10,772,327 | $5,551,325 | |
| **Orchard** | **9** | **5766** | **0.1** | | | **$1548** | | | **$8,926,944** | **0.1** |
| Provisioning services | | | | | | $375 | | | $2,163,441 | |
| Food | 1 | | | | | $21 | | | $122,738 | |
| Raw materials | 1 | | | | | $141 | | | $813,200 | |
| Water | 1 | | | | | $213 | | | $1,227,503 | |
| Regulating services | | | | | | $1103 | | | $6,358,456 | |
| Air quality | 1 | | | | | $229 | | | $1,319,556 | |
| Biodiversity protection | 1 | | | | | $232 | | | $1,334,899 | |
| Climate regulation | 1 | | | | | $192 | | | $1,104,766 | |
| Soil formation | 1 | | | | | $311 | | | $1,795,228 | |
| Water purification | 1 | | | | | $139 | | | $804,008 | |
| Cultural Services | | | | | | $70 | | | $405,047 | |
| Recreation | 1 | | | | | $70 | | | $405,047 | |
| **Temperate forest** | **63** | **2,884,571** | **74.5** | **$1334** | **$21,715** | **$5040** | **$3,834,709,420** | **$62,596,170,971** | **$14,538,868,801** | **93.8** |
| Provisioning Services | | | | $67 | $888 | $475 | $191,975,096 | $2,561,771,497 | $1,371,053,030 | |
| Bioprospecting | 1 | | | | | $8 | | | $24,184,245 | |
| Food | 4 | | | $0 | $432 | $242 | $599,779 | $1,247,000,114 | $697,379,641 | |
| Genetic resources | 1 | | | | | $19 | | | $54,229,938 | |
| Timber | 2 | | | $39 | $50 | $44 | $112,821,440 | $143,623,952 | $128,222,696 | |
| Water | 5 | | | $0 | $379 | $162 | $139,695 | $1,092,733,248 | $467,036,510 | |
| Regulating Services | | | | $1264 | $13,671 | $3524 | $3,633,654,443 | $39,394,646,032 | $10,165,400,181 | |
| Air quality | 1 | | | | | $852 | | | $2,457,834,607 | |
| Biodiversity protection | 8 | | | $7 | $5192 | $969 | $19,706,381 | $14,976,693,482 | $2,795,708,992 | |
| Biological control | 2 | | | $5 | $14 | $9 | | | $27,277,513 | |
| Climate regulation | 15 | | | $2 | $6999 | $1220 | $6,007,590 | $20,188,808,099 | $3,518,000,805 | |
| Erosion prevention | 2 | | | $2 | $115 | $58 | $5,000,654 | $330,802,621 | $167,901,637 | |
| Pollination | 1 | | | | | $376 | | | $1,084,598,758 | |
| Soil formation | 1 | | | | | $11 | | | $32,537,963 | |
| Water purification | 5 | | | $0 | $102 | $28 | $151,152 | $295,553,161 | $81,000,079 | |
| Water regulation | 1 | | | | | $0 | | | $539,827 | |
| Cultural Services | | | | $3 | $7155 | $1041 | $9,079,880 | $20,639,753,443 | $3,002,415,591 | |
| Cultural values | 1 | | | | | $2 | | | $5,422,994 | |
| Education | 1 | | | | | $0 | | | $1,279,944 | |
| Science/Research | 1 | | | | | $0 | | | $21,620 | |
| Tourism/Recreation | 11 | | | $1 | $7153 | $1039 | $2,355,322 | $20,633,028,885 | $2,995,691,033 | |
| **Grassland** | **42** | **151,394** | **3.9** | **$324** | **$2628** | **$1200** | **$49,120,964** | **$397,836,830** | **$181,718,223** | **1.2** |
| Provisioning services | | | | $70 | $758 | $340 | $10,543,718 | $114,688,284 | $51,526,905 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bioprospecting | 1 | | | | | $0 | | | $35,729 | |
| Food | 4 | | | $38 | $152 | $88 | $5,756,888 | $23,055,760 | $13,267,460 | |
| Genetic resources | 1 | | | | | $0 | | | $2,030 | |
| Raw materials | 2 | | | $6 | $33 | $20 | $959,481 | $4,975,597 | $2,967,539 | |
| Water | 3 | | | $25 | $572 | $233 | $3,789,589 | $86,619,168 | $35,254,147 | |
| Regulating services | | | | $220 | $1831 | $824 | $33,333,349 | $277,223,781 | $124,700,792 | |
| Air quality | 1 | | | | | $101 | | | $15,353,685 | |
| Biodiversity protection | 3 | | | $0 | $138 | $46 | $1,590 | $20,918,280 | $6,975,674 | |
| Biological control | 1 | | | | | $29 | | | $4,405,559 | |
| Climate regulation | 9 | | | $0 | $642 | $137 | $9084 | $97,123,566 | $20,670,672 | |
| Erosion prevention | 4 | | | $35 | $120 | $65 | $5,265,476 | $18,167,254 | $9,860,318 | |
| Pollination | 1 | | | | | $30 | | | $4,553,925 | |
| Soil formation | 2 | | | $7 | $247 | $127 | $996,171 | $37,423,739 | $19,209,955 | |
| Water purification | 4 | | | $13 | $166 | $107 | $2,036,309 | $25,140,791 | $16,246,738 | |
| Water regulation | 2 | | | $5 | $358 | $181 | $711,551 | $54,136,980 | $27,424,265 | |
| Cultural Services | | | | $35 | $39 | $36 | $5,243,897 | $5,924,766 | $5,490,526 | |
| Attractive landscapes | 1 | | | | | $34 | | | $5,157,578 | |
| Recreation | 3 | | | $1 | $5 | $2 | $86,320 | $767,189 | $332,949 | |
| **Barren land** | **0** | **224,537** | **5.8** | | | **$0** | | | **$0** | **0.0** |
| **Glaciers/Snow** | **0** | **258,866** | **6.7** | | | **$0** | | | **$0** | **0.0** |
| **Urban** | **3** | **3142** | **0.1** | | | **$5744** | | | **$18,049,159** | **0.1** |
| Climate regulation | 1 | | | | | $780 | | | $2,451,448 | |
| Recreation | 1 | | | | | $4950 | | | $15,553,407 | |
| Water regulation | 1 | | | | | $14 | | | $44,303 | |
| **Inland wetland** | **50** | **3528** | **0.1** | **$3596** | **$30,363** | **$14,183** | **$12,684,749** | **$107,115,386** | **$50,034,833** | **0.3** |
| Provisioning services | | | | $2244 | $5470 | $3623 | $7,916,161 | $19,298,764 | $12,782,686 | |
| Food | 5 | | | $0 | $914 | $167 | $777 | $3,225,092 | $590,860 | |
| Genetic resources | 1 | | | | | $9 | | | $32,808 | |
| Raw materials | 7 | | | $0 | $85 | $19 | $995 | $299,180 | $67,581 | |
| Water | 3 | | | $2234 | $4462 | $3427 | $7,881,581 | $15,741,683 | $12,091,437 | |
| Regulating services | | | | $1305 | $19,560 | $8561 | $4,602,781 | $69,004,200 | $30,202,285 | |
| Biodiversity protection | 5 | | | $9 | $1,584 | $452 | $32,352 | $5,586,426 | $1,593,363 | |
| Biological control | 1 | | | | | $13 | | | $45,007 | |
| Climate regulation | 3 | | | $51 | $292 | $140 | $178,432 | $1,031,317 | $492,745 | |
| Erosion prevention | 1 | | | | | $72 | | | $252,779 | |
| Disturbance regulation | 5 | | | $204 | $8495 | $3070 | $719,601 | $29,967,893 | $10,831,941 | |
| Pollination | 1 | | | | | $14 | | | $48,913 | |
| Soil formation | 2 | | | $25 | $209 | $117 | $89,176 | $737,726 | $413,451 | |
| Water purification | 3 | | | $489 | $1947 | $1002 | $1,726,428 | $6,867,711 | $3,535,826 | |
| Water regulation | 2 | | | $428 | $6935 | $3682 | $1,510,094 | $24,466,428 | $12,988,261 | |
| Cultural Services | | | | $47 | $5333 | $1998 | $165,807 | $18,812,422 | $7,049,862 | |
| Cultural values | 5 | | | $9 | $2067 | $774 | $33,161 | $7,292,176 | $2,732,112 | |
| Tourism/Recreation | 6 | | | $38 | $3266 | $1,224 | $132,645 | $11,520,246 | $4,317,750 | |
| **Lakes/Rivers** | **29** | **28,620** | **0.7** | **$1160** | **$15,540** | **$4827** | **$33,206,067** | **$444,756,605** | **$138,143,725** | **0.9** |
| Provisioning services | | | | $494 | $11,855 | $3,060 | $14,145,105 | $339,305,925 | $87,586,099 | |
| Energy | 4 | | | $56 | $6534 | $1723 | $1,599,729 | $187,003,916 | $49,319,774 | |
| Food | 3 | | | $13 | $53 | $38 | $362,769 | $1,520,554 | $1,097,144 | |
| Raw materials | 1 | | | | | $1 | | | $36,352 | |
| Water | 10 | | | $34 | $2586 | $1297 | $984,449 | $74,011,981 | $37,132,829 | |
| Regulating Services | | | | $390 | $2681 | $1178 | $11,161,807 | $76,733,122 | $33,722,564 | |
| Biodiversity protection | 1 | | | | | $316 | | | $9,033,995 | |
| Climate regulation | 1 | | | | | $58 | | | $1,668,812 | |
| Water purification | 3 | | | $16 | $2307 | $804 | $458,999 | $66,030,315 | $23,019,756 | |
| Cultural Services | | | | $276 | $1003 | $588 | $7,899,155 | $28,717,558 | $16,835,061 | |
| Recreation | 6 | | | $276 | $1003 | $588 | $7,899,155 | $28,717,558 | $16,835,061 | |
| **Total** | | **3,870,151** | | | | | | | **$15,502,874,261** | |

ignores the contributions of natural capital and many other factors (such as the other domains of GNH). The benefits transfer method applied in this paper is not very precise, but it improves the accuracy of monetary measures of economic welfare.

Alternative measures of progress, like the Index of Sustainable Economic Welfare (ISEW) or a variant called the Genuine Progress Indicator (GPI) take account of economic, social, and environmental realities that are ignored in GDP accounting to arrive at a better approximation of ‘‘National Well-being .’’ ISEW and GPI start with personal consumption expenditures, but weigh them by income distribution to account for the fact that a dollar's worth of additional income produces far more welfare for a poor person than a rich one. It then adds positive activities that are left out of GDP like volunteer work and household labor, and subtracts activities that are included in GDP but are negatives, like the costs of crime, commuting, pollution, and natural capital depletion (Daly and Cobb, 1989; Lawn, 2005). Results show that while the United States' GDP has steadily increased since 1950 (with the occasional recession), GPI peaked around 1975 and has been relatively flat or declining ever since (Beddoe et al., 2009).

So what do the Bhutanese mean by GNH? Bhutan has recently completed a survey of 8000 of its citizens, asking them over 200 questions about various aspects of their lives. The survey includes measures of ‘‘subjective well-being’’ or SWB—an area of research that is getting increasing attention in many quarters of science and policy as part of the emerging ‘‘science of happiness’’ (Easterlin, 2003; Layard, 2005). In the US, for example, SWB surveys show flat or dropping scores over the last several decades, consistent with the flattening and declining GPI estimates (Hernández-Murillo and Martinek, 2010).

But the GNHC and others in Bhutan recognize that there are other, more objective elements that are also important in assessing their country's overall well-being . For example, ecosystem services, an important aspect of one of the nine domain used in GNH, are the often un-accounted for benefits that people derive from nature—clean air, water, soil, a stable climate, recreational, and spiritual opportunities to connect with nature, and many more. A previous study (Costanza et al., 1997) estimated that globally these services were worth, in aggregate, more than all of global GDP combined. But these services do not yet adequately appear in any country's national accounts. Bhutan sees itself as a leader in rectifying this situation. It hosted a workshop in Thimphu, the capital in March 2011 with over seventy representatives from several government agencies, universities, and others, to discuss how best to do this. The contribution of natural capital in the GNH framework is ultimately its contribution to overall sustainable human well-being as expressed by the nine domains of GNH.

As a first step in this process, we have estimated the value of ecosystem services in Bhutan using a simple benefit transfer methodology based on land use. This initial estimate sets the stage for further work. However, estimating monetary values of ecosystem services is only an initial step in estimating its contribution to GNH. The fact that this study only estimated the benefits from natural capital does not imply that natural capital is the only or the most important contribution to GNH. Using monetary valuation also does not imply that these are exchange values, where one dollar's worth of any other commodity is a perfect substitute for one dollar's worth of natural capital. Most ecosystem services are best viewed a public goods that cannot (or should not) be commodified or exchanged in markets. Nevertheless, estimating their value in terms of their contribution to human well-being expressed in monetary units, is important for policy decision-making and national accounting.

## 2. Methods

Ecosystem service valuation (ESV) is the process of assessing the contributions of ecosystem services to sustainable human well-being (Costanza and Folke, 1997). One application of ESV is natural capital accounting, that is, to provide for comparisons of natural capital to physical and human capital in regard to their contributions to human welfare (Liu et al., 2010).

Various methods have been used to estimate both the market and non-market components of the value of ecosystem services (Farber et al., 2006). In this study, benefit transfer was used to value the various ecosystems within the country of Bhutan. Benefit transfer is the process of utilizing existing valuation studies or data to estimate the value of ecosystem services in one location and transfer them to value ecosystem services in a similar location (Costanza et al., 1997). The transfer method involves obtaining an economic estimate for the value of market and nonmarket services through the analysis of a single study, or group of studies, that have been previously carried out to value similar services. Benefit transfer is often used when resources and/or time is unavailable to do a more detailed, on-the-ground, data collection study (Wilson and Hoehn, 2006). However, there are limitations to the use of benefit transfer including data

**Table 2**
Summary table of ecosystem services values for the 9 land-cover types.

| Land cover types | # of Vals | Total area (ha) | Total area (%) | Min value ($US/ha/year) | Max value ($US/ha/year) | Mean value ($US/ha/year) | Mean value (BTN/ha/year) | Min value ($US/year) | Max value ($US/year) | Mean value ($US/year) | Mean value (NU/year) | Total value (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cropland | 17 | 309,728 | 8.0 | $798 | $2864 | $1831 | 89,722 | 224,030,375 | 887,156,484 | $567,132,576 | 27,789,496,216 | 3.7 |
| Orchard | 9 | 5766 | 0.1 | | | $1548 | 75,860 | | | $8,926,944 | 437,420,263 | 0.1 |
| Temperate Forest | 63 | 2,884,571 | 74.5 | $1334 | $21,715 | $5040 | 246,971 | 3,834,709,420 | 62,596,170,971 | $14,538,868,801 | 712,404,571,273 | 93.8 |
| Grassland | 42 | 151,394 | 3.9 | $324 | $2628 | $1200 | 58,815 | 49,120,964 | 397,836,830 | $181,718,223 | 8,904,192,949 | 1.2 |
| Barren land | 0 | 224,537 | 5.8 | | | $0 | | | | $0 | 0 | 0.0 |
| Glaciers/ Snow | 0 | 258,866 | 6.7 | | | $0 | | | | $0 | 0 | 0.0 |
| Urban | 3 | 3142 | 0.1 | | | $5744 | 281,473 | | | $18,049,159 | 884,408,770 | 0.1 |
| Inland wetland | 50 | 3528 | 0.1 | $3596 | $30,363 | $14,183 | 694,967 | 12,684,749 | 107,115,386 | $50,034,833 | 2,451,706,812 | 0.3 |
| Lakes/ Rivers | 29 | 28,620 | 0.7 | $1160 | $15,540 | $4827 | 236,513 | 33,206,067 | 444,756,605 | $138,143,725 | 6,769,042,509 | 0.9 |
| **Total** | | **3,870,151** | **100** | | | **$34,374** | **BTN 1,684,321** | | | **$15,502,874,261** | **759,640,838,791** | **100** |

**Table 3**
Distribution table of who benefits from the 22 ecosystem services present in Bhutan.

| | Min value ($US/ha/year) | Max value ($US/ha/year) | Mean value ($US/ha/year) | Min value ($US/year) | Max value ($US/year) | Mean value ($US/year) | Percent of total benefits (%) | | | Total value ($US/year) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | International | National | Local | International | National | Local |
| Provisioning services | | | | | | | | | | | | |
| Bioprospecting | | | $9 | | | $24,219,974 | 90 | 10 | | 21,797,976 | 2,421,997 | 0 |
| Energy | $56 | $6534 | $1723 | $1,599,729 | $187,003,916 | $49,319,774 | | 100 | | 0 | 49,319,774 | 0 |
| Food | $122 | $1658 | $645 | $28,701,834 | $1,307,769,050 | $739,932,418 | | | 100 | 0 | 0 | 739,932,418 |
| Genetic resources | | | $28 | | | $54,264,776 | 50 | 50 | | 27,132,388 | 27,132,388 | 0 |
| Other Raw materials | $7 | $118 | $192 | $960,477 | $5,274,777 | $7,181,085 | | | 100 | 0 | 0 | 7,181,085 |
| Timber | $39 | $50 | $44 | $112,821,440 | $143,623,952 | $128,222,696 | | 50 | 50 | 0 | 64,111,348 | 64,111,348 |
| Water | $2294 | $7999 | $5396 | $12,795,314 | $1,269,106,080 | $572,524,306 | 80 | 20 | | 458,019,445 | 114,504,861 | 0 |
| Regulating services | | | | | | | | | | | | |
| Air quality | | | $1236 | | | $2,490,989,911 | | | 100 | 0 | 0 | 2,490,989,911 |
| Biodiversity protection | $92 | $8844 | $3017 | $43,145,531 | $15,600,916,792 | $3,125,208,830 | 50 | 50 | | 1,562,604,415 | 1,562,604,415 | 0 |
| Biological control | $5 | $14 | $80 | | | $40,462,399 | 20 | 40 | 40 | 8,092,480 | 16,184,959 | 16,184,959 |
| Climate regulation | $53 | $7933 | $2621 | $6,195,105 | $20,286,962,983 | $3,573,730,043 | 100 | | | 3,573,730,043 | 0 | 0 |
| Erosion prevention | $87 | $370 | $288 | $26,000,294 | $390,763,749 | $206,778,753 | | 25 | 75 | 0 | 51,694,688 | 155,084,065 |
| Disturbance regulation | $204 | $8495 | $3070 | $719,601 | $29,967,893 | $10,831,941 | 5 | 25 | 70 | 541,597 | 2,707,985 | 7,582,359 |
| Pollination | | | $439 | | | $1,095,024,476 | | | 100 | 0 | 0 | 1,095,024,476 |
| Soil formation | $187 | $671 | $752 | $49,217,055 | $104,539,971 | $111,211,704 | 50 | 25 | 25 | 55,605,852 | 27,802,926 | 27,802,926 |
| Water purification | $519 | $4522 | $2256 | $4,372,888 | $393,591,979 | $178,673,700 | 80 | 10 | 10 | 142,938,960 | 17,867,370 | 17,867,370 |
| Water regulation | $433 | $7293 | $3877 | $2,221,645 | $78,603,409 | $40,996,657 | 25 | 50 | 25 | 10,249,164 | 20,498,328 | 10,249,164 |
| Cultural services | | | | | | | | | | | | |
| Attractive landscapes | | | $34 | | | $5,157,578 | | 20 | 80 | 0 | 1,031,516 | 4,126,062 |
| Cultural values | $9 | $2067 | $776 | $33,161 | $7,292,176 | $8,155,106 | | 50 | 50 | 0 | 4,077,553 | 4,077,553 |
| Education | | | | | | $1,279,944 | | 50 | 50 | 0 | 639,972 | 639,972 |
| Science/Research | | | | | | $21,620 | 80 | 10 | 10 | 17,296 | 2162 | 2162 |
| Tourism/Recreation | $316 | $11,462 | $7891 | $10,803,765 | $20,684,806,205 | $3,038,686,572 | 80 | 10 | 10 | 2,430,949,258 | 303,868,657 | 303,868,657 |
| **Total** | | | | | | **$15,502,874,261** | **53** | **15** | **32** | **$8,291,678,874** | **$2,266,470,901** | **$4,944,724,486** |

availability and reliability, distribution of data on services and values over biomes, difference in socio-economic context, spatial heterogeneity, and others (de Groot et al., 2012). The transfer itself refers to the application of values and other information from the original study site to a new site (Brookshire and Neill, 1992; Desvouges et al., 1998).

In order to estimate the total value of ecosystem services, we needed estimates of the total extent of the ecosystems themselves. The National Land Commission of Bhutan was able to provide a land cover classification scheme with 51 categories to represent land use in Bhutan. These 51 categories were aggregated into nine land cover categories (cropland, orchard, temperate forest, grassland, barren land, glacier/snow, inland wetland, and lakes/rivers) to correlate them with previously valued land uses.

The Ecosystem Services Valuation Database (ESVD), compiled by the international Ecosystem Services Partnership (ESP—www.es-partnership.org), was used to determine the values for each of the land cover types similar to those that are located in Bhutan. We selected studies valuing similar goods or services to those found in Bhutan and in locations at similar latitudes as Bhutan. We converted all estimates into 2005 U.S. dollars per hectare per year, and organized the values corresponding to the services within each of the land cover types (Table 1). From this we were able to determine the minimum, maximum, and mean of the economic values for most services in each land cover (Rosenberger and Loomis, 2003). We then multiply the mean values per hectare by the area of each land cover. The results showed the estimated total value each service provides from each land cover within Bhutan in $US 2005 per year. That result was also converted to Ngultrum, the Bhutan currency, which is pegged to the Indian rupee and, at the time of writing (February 2012), had an exchange rate to the $US of 49 to 1. A summary of these results is shown in Table 2.

To estimate who benefits from these services, regardless of which land cover produced them, an expert panel estimated what percentage of each service was utilized internationally, nationally, or locally (Table 3). This panel's estimates were a rough first approximation based on their knowledge and expertise of the ecosystem services involved.

## 3. Results

The accompanying maps show the location of valued ecosystems and their services. Fig. 1 shows a map of the 51 categorizations of the land cover classification scheme. By knowing the location and area of each of the land cover types and the dollar values per hectare per year, we are able to overlay the values and the land cover types to estimate the total values for each area of Bhutan based on prior studies of similar land types and the ecosystem services they provide (Fig. 2). These values were split up into six categories, with values ranging from $0 to $20,000/ha/yr. As a way to better show the location of the different values, Fig. 2 was split up into six individual maps (Fig. 3), each one showing one of the six value categories.

There is considerable variability in ecosystem service values delivered by different land cover types. On a per hectare basis, inland wetlands are estimated to provide the highest annual values ($14,183/ha/yr), followed by urban areas ($5,744/ha/yr). Urban has a significantly higher per hectare value then many of the other land cover types due to the close proximity to human populations. However, both of these land-cover types represent a small percentage of the total land area in Bhutan. At the other end of the value spectrum, grasslands ($1,200/ha/yr) and orchards ($1,548/ha/yr) provide the lowest annual values, disregarding barren land and glacier/snow (Fig. 4).

Bhutan covers approximately 3.9 million hectares in land area (39,000 square kilometers). Looking at the land cover map (Fig. 1) we see that the majority (74.5%) is covered in forest, followed by cropland at 8%. Taking into account the total area of each land cover type and the value of that land cover, we find that the Bhutan forests have the greatest value of $14.5 billion/yr, making up 93.8% of the total value of Bhutan's ecosystem services (Table 1, Fig. 5). Cropland, covering only 8% of land area, has the

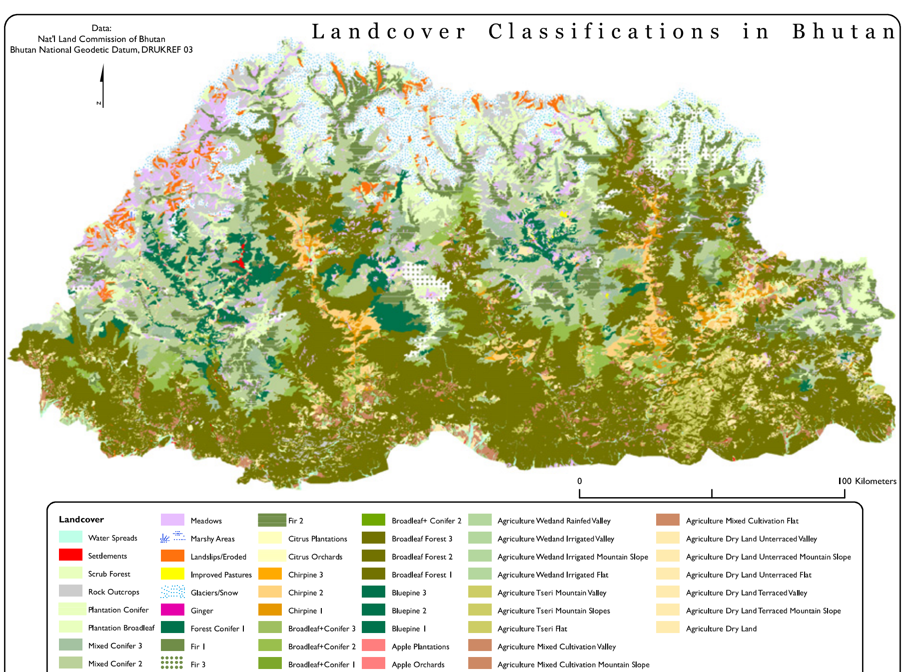


**Fig. 1.** Landcover classification in Bhutan. A map of the 51 categorizations of the land cover classification scheme.

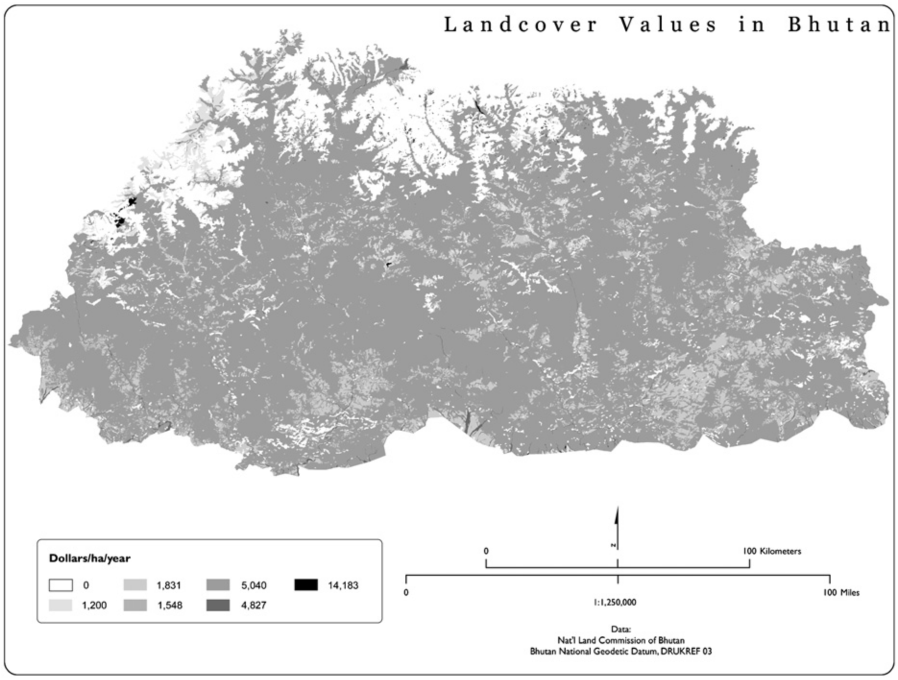


**Fig. 2.** Ecosystem service values in Bhutan. An overlay of the values and the land cover types, estimating total values for each area of Bhutan.

second largest value of $567 million/yr, amounting to 3.7% of the total value of the ecosystem services in Bhutan. This value is comparable to the contribution of agriculture to the Bhutanese GDP of about $640 million in 2003 (Tobgay, 2005). The total value of market and nonmarket ecosystem services in Bhutan is estimated at $15.5 billion/yr.[1]

For each land cover type, multiple studies were used to estimate the value provided by the various ecosystem services. A minimum and maximum value for each of the services from the studies, and the number of studies used for each service can be seen in Table 2.

Fig. 2 shows that a significant portion of northern Bhutan has little value associated with the ecosystem services. These areas are mainly glaciers/snow and barren land, a land use type whose ecosystem service values have not been well researched yet. Such ecosystems likely have significant values both as water sources and also due to their high tourist/recreation value in countries like Bhutan. For example, by estimating the number of trekkers and how much time they spend trekking in the high mountains, a recreation value for Bhutan's glaciers/snow and barren land could be determined. But this has not been done yet. For this and many other reasons, the $15.5 billion estimate for the value of Bhutan's ecosystem services is almost certainly an under-estimate .

Because forests make up such a large portion of Bhutan's land cover, the majority of the value visible on the map is due to forests, between $5001 and $10,000 per hectare per year (250,001–700,000 Ngultrum/ha/yr). However, there are areas of Bhutan with far higher ecosystem services values on a per hectare basis. There are also areas, in the western part of the country, primarily inland wetlands, where the ecosystem services values are between $10,001 and $20,000 per hectare per year (700,000–1,000,000 NU/ha/yr). This is the location of the majority of the inland wetlands, which are valued at around $14,183/ha/yr.

It should be emphasized that these estimates are merely first approximations and are not extremely precise. However they are much more accurate that no estimates at all, or default estimates of zero. As has often been said, it is better to be approximately right than precisely wrong. It should also be noted that GDP estimates are themselves also just approximations and should not be given more precision than they deserve.

Determining who benefits from these services is also a critical aspect, addressed in Table 3. An expert panel estimated that 53% of the value of the 22 ecosystem services that existed in Bhutan benefited people outside the country, with the largest service being climate regulation ($3.5 billion) followed by tourism/recreation ($2.4 billion). Fifteen percent of services benefited Bhutan as a whole, and 32% benefited local people, most of that being through air quality regulation ($2.5 billion), followed by pollination ($1.1 billion), and food ($740 million) (Table 3, Fig. 6).

## 4. Discussion

There are various direct and indirect methods to estimate the value of ecosystem services,. Many of these vary in the resources, both financial and human, that they require, but also in the accuracy and precision of the results that are produced.

As noted before, the majority (74.5%) of Bhutan is covered in forest. Bhutan's constitution mandates "a minimum of 60% of the total land under forest cover for all times to come." Today 43% of the total land area is contained within the Protected Areas system with an additional 7 percent of the total designated as biological corridors (Royal Government of Bhutan, 2010). Cropland is the other critical land cover, as 69% of the population lives in rural settings (Royal Government of Bhutan, 2010).

Utilizing a geographical information system (GIS) allows us not only to determine the value of ecosystem services in the country as a whole but also the specific locations of the most

[1] One previous estimate of the value of ecosystem services in Bhutan was part of a global analysis (Sutton and Costanza, 2002). This estimate was based on much less precise global land use data and a less complete data set of per hectare values. Converted to $US2005, this estimate was $3.5 billion/yr. This is consistent with our expectation that as more and better data is accumulated, the estimated value of ecosystem services will increase, all else being equal. Therefore, our current estimate is almost certainly still a conservative one.

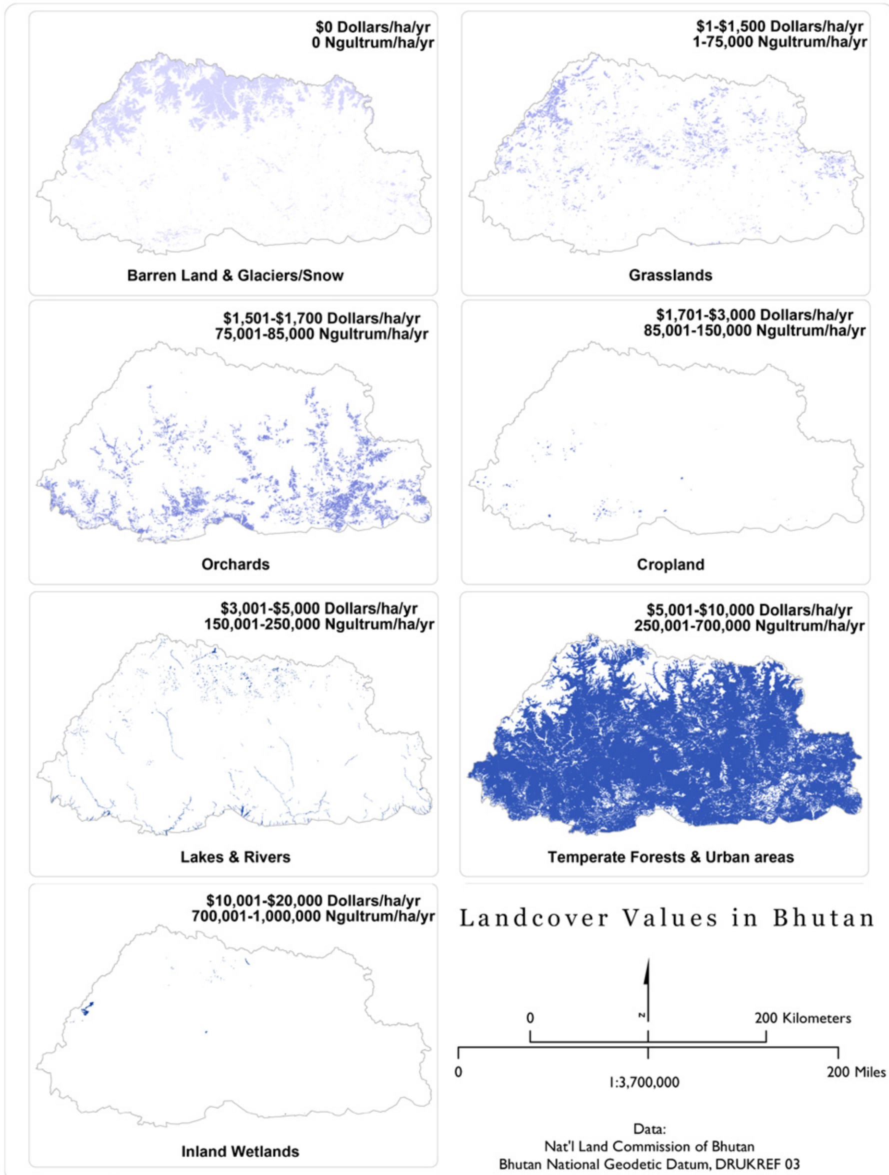


**Fig. 3.** Ecosystem service values in Bhutan in various value ranges. Fig. 2 split up into six individual maps, each one showing one of the six value categories.

valuable ecosystems. For example, we see in Fig. 3 that inland wetlands, mostly located in the eastern part of the country, are very valuable. Such knowledge allows for appropriate policies to ensure that those ecosystems are conserved.

Fig. 6 shows that the majority (53%) of ecosystem services created within Bhutan benefit people outside the country of Bhutan. As of today, very few successful institutions or mechanisms have successfully captured compensation for values that flow across political boundaries. One recommendation is that, as a start, Bhutan enters these values in their government's accounts as foreign aid. Such forms of aid, especially to developing countries, is more valuable than military aid.

While this analysis provides much information about the approximate value and location of ecosystem services in Bhutan, more elaborate analyses are necessary to define more accurate values and more precise locations and influences of the services. It will also be necessary to determine the condition of the ecosystems and the change in their state over time. The condition of an ecosystem determines the amount of services it can provide. This condition may vary across a single ecosystem. Benefit transfer assumes a constant average condition of the ecosystems as it integrates multiple values from multiple studies, which have varying conditions. Such qualitative changes will affect the value of the services the ecosystems provide.

Further analysis is necessary and will require multiple phases, utilizing various techniques and requiring increasing resources. With each level, the values become more precise and accurate, but also more data intensive and expensive to estimate. Four levels of ecosystem service analysis have been defined as follows:

### 4.1. Level 1: basic value transfer

Value transfer is the process of utilizing societies' stock of knowledge rather then doing original research to determine the ecosystem service values (Loomis and Rosenberger, 2006). The process transposes the monetary values of ecosystem services estimated at one site, through market-based or non-market-based economic valuation techniques, to another site (Roy, 2000).

Although this form of analysis is used in studies at all scales (Costanza et al., 1997; Liu et al., 2010; Troy and Wilson, 2006),

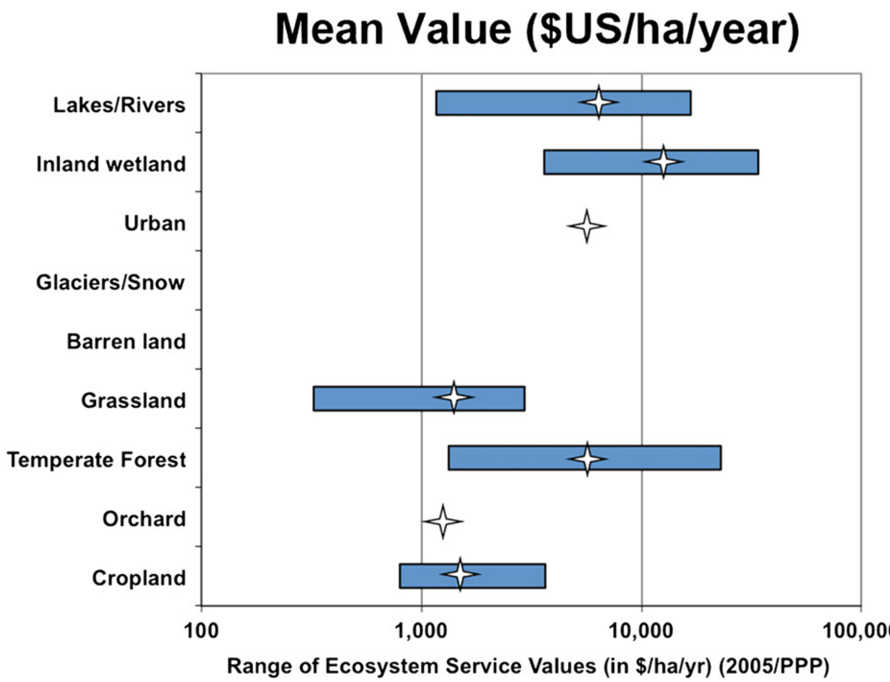


**Fig. 4.** Ranges of ecosystem service values per hectare per year. Stars show means.

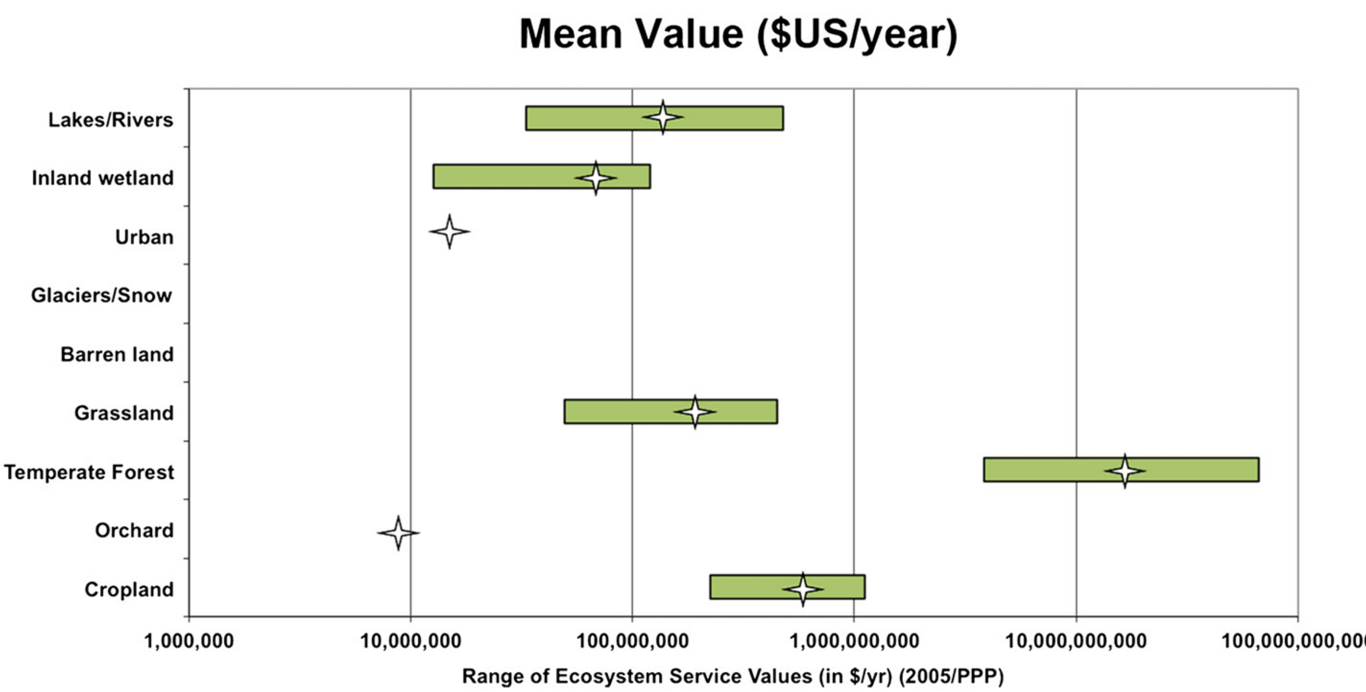


**Fig. 5.** Ranges of ecosystem service for nine ecosystems in Bhutan, in US dollars per year. Stars show means.

basic value transfer has both significant limitations and advantages. The greatest advantage is its cost-effectiveness (Navrud and Ready, 2007). Because it utilizes previously completed ecosystem service valuations, the transferring of these values takes minimal time and effort since it assumes that the values are constant over the ecosystem type. This assumption presents a potential miscalculation since most ecosystems are different and the populations that the services benefit vary greatly as well.

Basic value transfer, which is used in this preliminary study, is usually used as an initial, crude means of determining the value of the ecosystem services in a given area to an approximate order of magnitude. It is the least expensive and also the least precise analysis type.

### 4.2. *Level 2: expert modified value transfer*

Although similar to a basic value transfer analysis, this analysis requires experts, with knowledge of the local ecosystem conditions, to adjust the transposed values to apply to the local site more directly. Such an analysis is more expensive than the basic value transfer, but does provide values that are more accurate and precise than just a basic value transfer. It does not, however,

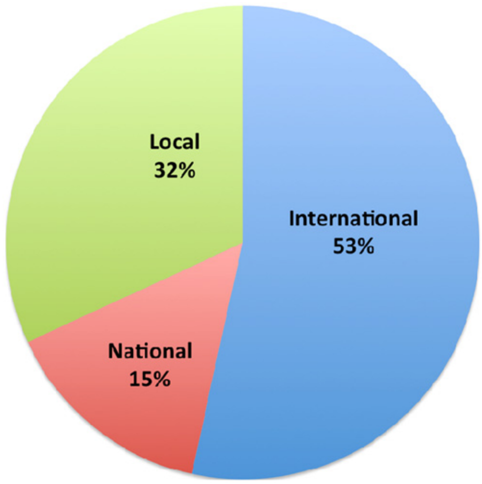


**Fig. 6.** Distribution of who benefits from services provided by Bhutan's ecosystems.

require primary data collection and is less expensive than on the ground original research. One example of this approach is Batker et al. (2008).

### 4.3. Level 3: statistical value transfer

By compiling valuation studies into a meta-analysis and building a statistical model of spatial and other dependencies in valuation studies, more accurate and precise values can be determined. Such statistical models are used to identify which landscape characteristics, valuation methods, study sites, etc. have the greatest effect on the estimated ecosystem services it provides. By knowing the contribution of these characteristics to the value of the ecosystem service, the variance can be better attributed to different sources, and more accurate values thereby obtained. One example of this approach is Liu and Stern (2008).

### 4.4. Level 4: spatially explicit functional modeling

The modeling of ecosystems allows for a more complete accounting of the interconnected factors that contribute to the value of ecosystem services along with their spatial patterns and dynamics. These factors must include the human population density and the society that benefits from the ecosystem services. For example, modeling allows for the quantification of the effects of varying environmental conditions derived from land use change over time. These models can be presented in multiple forms, including statistical (Costanza et al., 2008) and as dynamic systems simulations (Boumans et al., 2002).

Spatially explicit functional modeling is the most time consuming and expensive of the four levels of analysis. However, it provides temporal information, spatially detailed information, and the ability to run scenarios to improve management.

**Ultimately**, determining the contribution of ecosystem services to sustainable human well-being is the end goal of valuation. Bhutan, utilizing GNH as their measure of well-being, has begun the process of such integration. Environment is one out of the nine domains in GNH making it critical to determine how natural capital and ecosystems services contribute both directly and in interaction with the other eight domains, to sustainable human well-being .

The next steps in Bhutan are to undertake more accurate valuations of the country's ecosystem services. This will require on-the-ground data collection by the various ministries, agencies, and offices in the Bhutan government. Such data collection and valuation can be done through various approaches including revealed-preference, stated-preference, and cost-based methods (Farber et al., 2006). In the hopes of incorporating the value of ecosystem services into the yearly national accounts, regular data collection will have to be done to assess the changes in the condition and quality of the country's ecosystem services.

## 5. Conclusions

Our initial estimates of the value of ecosystem services using simple benefit transfer techniques have shown that these benefits are a significant contributor to human well-being in Bhutan. Forests represent by far the largest contributor to ecosystem services, and Bhutan has pledged to be a global carbon dioxide sink in perpetuity by preserving its forest cover. Other ecosystems, like lakes and rivers and inland wetlands are very valuable per ha, but occupy fairly small areas of the country.

These initial estimates highlight the value of ecosystem services in Bhutan, and set the stage for more elaborate and precise estimates to follow.

## Acknowledgments

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