# A Guide to
# Valuing Natural Resources Wealth

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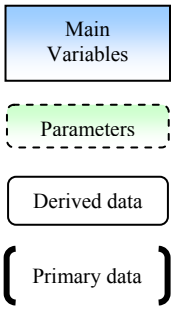
Key:



## Valuing Natural Resources Wealth – A Basic Framework

There are essentially three steps involved:

1. Estimation of current rents: these are obtained by multiplying the quantity of the resource produced or extracted by the unit rent. Unit rent is the difference between the price of the resource and the cost of making it available. Unit rents are often computed as the product of price and a rental rate. In the case of agricultural land, rents are calculated as the value of production minus the cost of agricultural inputs.
2. Forecast of future rents: to project rents over the future, assumptions on the growth rate of rents are needed. Future rents are calculated as the product of current rents by a (usually constant) growth factor:

$$R_t = R_{t^*}(1+g)^{t^*-t}$$

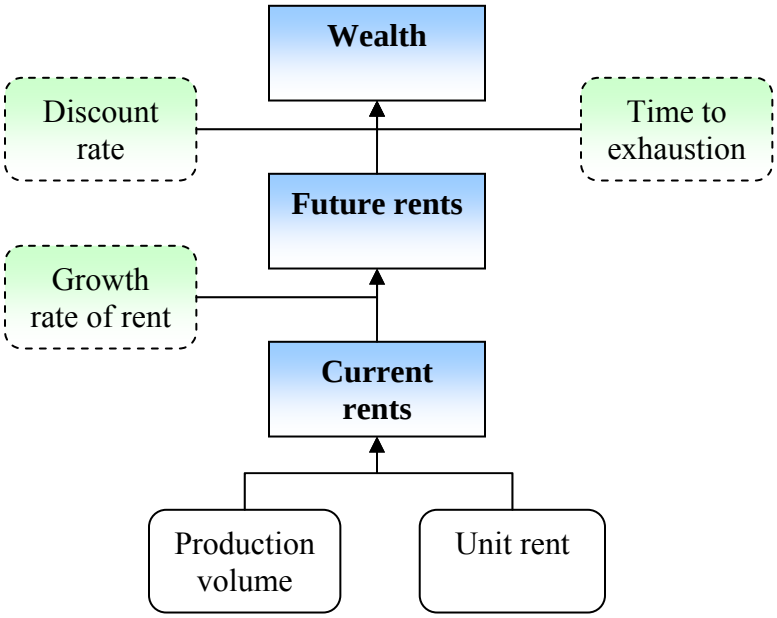
3. Estimation of wealth: wealth is estimated as the present value of future rents over the lifetime of the resource. For any given discount rate $r$ and resource lifetime $T$, we have that wealth at time $t^*$, $W_{t^*}$ is:

$$W_{t^*} = \sum_{t=t^*}^{t^*+T-1} \frac{R_t}{(1+r)^{t-t^*}}$$

The calculations rely on a series of key parameters:

- Growth rate of rents: the estimation of future rents requires specific assumptions regarding the evolution of demand and supply over time. The calculations here assume constant growth rates in the case of sub-soil assets and agricultural land. For timber rents are assumed to stay constant.
- Time to exhaustion of the resource: the life span of a resource depends on several factors, including the total stock available, the rate of extraction of the resource and general market conditions.
- Discount rate: the Social Rate of Return on Investment (SRRI) is used. SRRI is the discount rate that a government would choose in allocating resources across generations. The SRRI in general differs from country to country. In industrialized economies it ranges between 2% and 4%. For simplicity, a constant 4% rate was assumed for all countries.

*Figure 1: General Framework for the Estimation of Natural Resources Wealth*



**Sub-soil assets**

The calculations take place separately for the following assets: oil, natural gas, hard coal, soft coal, bauxite, copper, gold, iron ore, lead, nickel, phosphate rock, silver, tin, zinc).

Highlights:

- Price of the resource is calculated as world average price
- Rental rate calculation uses data on extraction costs for a selected subset of countries. Each one of the remaining countries is then assimilated to a representative country for which cost data is available
- Growth rate of rents is assumed constant and depends on the discount rate $r$, which is 4%, and the cost curve curvature $\varepsilon$, assumed to be 1.15
- The life-time of the resource is assumed to be 20 years;

*Figure 2: Subsoil wealth estimation - Flowchart*

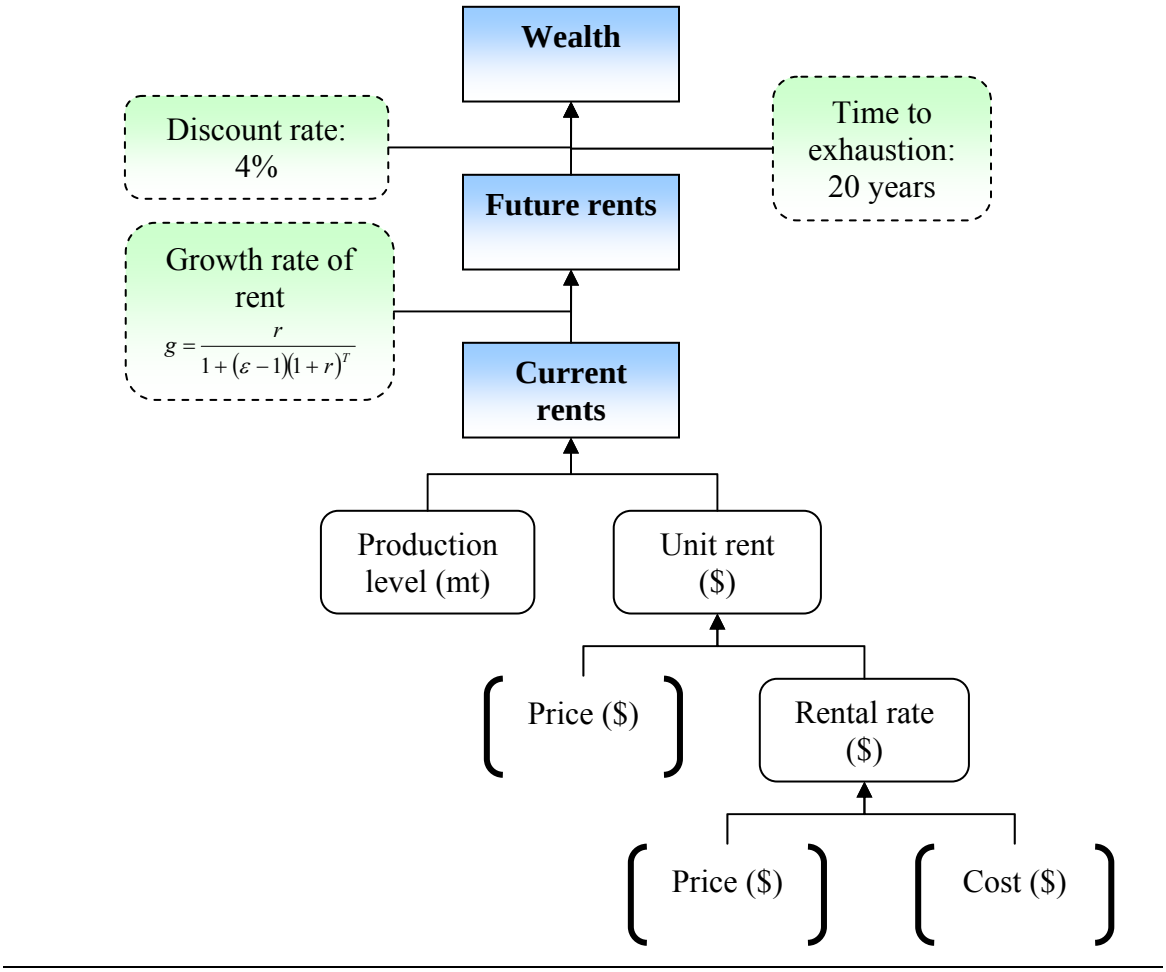


*Table 1. Sub-soil wealth – Variables used and Sources*

| ***Code*** | ***Item*** | ***Use*** | ***Coverage*** | ***Sources*** | ***Formula*** |
|---|---|---|---|---|---|
| PRO | Production level (mt) | To calculate rents | All countries | IEA, BP, UNMBS, USGS | None |
| PRI | Price of resource ($) | To calculate rents | Global | IEA, BP, UNMBS, USGS | None |
| COS | Cost of extraction ($) | To calculate rents | Selected countries | Sector reports | None |
| RRT | Rental rate | To calculate rents | Selected countries | Calculated | RRT = (PRI – cost)/PRI |
| UNR | Unit rent ($) | To calculate rents | Selected countries | Calculated | UNR = PRI * RRT |
| $R_{t^*}$ | Rents ($) | To predict future rents | All countries | Calculated | $R_{t^*}$ = PRO * UNR |
| RTG | Assumed growth rate of rents | To predict future rents | Global | Literature | $RTG = \frac{r}{1+(\varepsilon-1)(1+r)^T}$ ε = 1.15 is the elasticity of extraction cost to the level of extraction. Ref. Vincent (1996) |
| $R_t$ | Future rents (Constant $) | To estimate wealth | All countries | Calculated | $R_t = R_{t^*}(1+g)^{t^*-t}$ |
| r | Discount rate | To estimate wealth | Global | Literature | None |
| WEA | Wealth ($) | | All countries | Calculated | $WEA = \sum_{t=t^*}^{t^*+T-1} \frac{R_t}{(1+DCT)^{t-t^*}}$ |

References: Vincent, J. (1996) "Resource Depletion and Economic Sustainability in Malaysia," Development Discussion Paper No. 542. Harvard Institute for International Development.

## Forest (Timber assets)

The calculations combines roundwood and fuelwood.

Highlights:

- Price of standing timber is estimated as a weighted average (weighted by production volumes) of the export unit value of roundwood and a world average price of fuelwood
- Since production costs are not available for all countries, rental rates are estimated using available studies and consultation with World Bank experts
- Growth rate of rents is assumed to be zero.
- Calculating the life-time of the resource is very important since forests may be (i) managed sustainably thus producing rents forever or (ii) unsustainably thus determining a shorter life span.
- Time to exhaustion is the ration between forest volume available for production and net depletion
- Forest volume available for production is estimated using data on forest cover accessible for timber extraction (i.e. within 50km of infrastructure) and the forest specific volume per hectare.
- Net depletion is the difference between production and the forest specific annual increment.

*Figure 3: Timber wealth estimation - Flowchart*

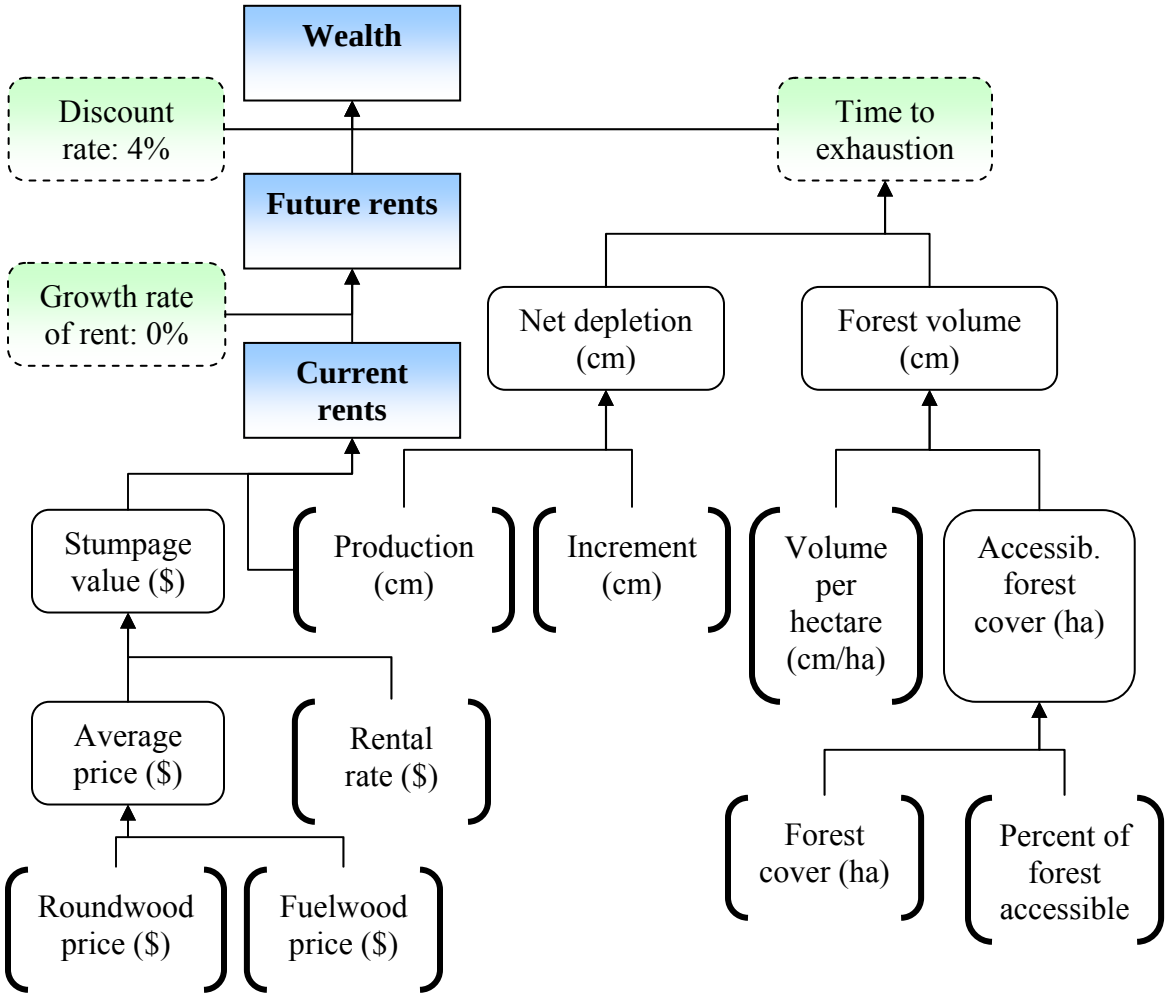


*Table 2. Timber wealth – Variables used and Sources*

| ***Code*** | ***Item*** | ***Use*** | ***Coverage*** | ***Sources*** | ***Formula*** |
|---|---|---|---|---|---|
| RWP | Roundwood price ($) | To calculate average price of timber | All countries | FAO | None |
| FWP | Fuelwood price ($) | To calculate average price of timber | Selected countries | Sector reports | None |
| PRI | Timber price | To calculate stumpage value | All countries | Calculated | PRI = RWP*a + FWP*(1-a)<br>a = share of roundwood in total timber production |
| RRT | Rental rate | To calculate stumpage value | Forest types | Sector reports | None |
| STP | Stumpage value | To calculate current rents | All countries | Calculated | STP = PRI*RRT |
| PRO | Production level (cm) | To calculate current rents and net depletion | All countries | FAO | None |
| INC | Increment (cm) | To calculate net depletion | Forest types | Sector reports | None |
| NDP | Net depletion (cm) | To calculate time to exhaustion | All countries | Calculated | NDP = PRO – INC |
| FOC | Forest cover (ha) | To calculate accessible forest | All countries | FAO | None |
| ACC | Percent of forest accessible | To calculate accessible forest | All countries | Sector reports | None |
| FOA | Accessible forest cover | To calculate Forest volume | All countries | Calculated | FOA = FOC * ACC |
| VHA | Volume per hectare of forest (cm/ha) | To calculate forest volume | All countries | Sector reports | None |
| FOV | Forest Volume | To calculate time to exhaustion | All countries | Calculated | FOV = FOA * VHA |
| T | Time to exhaustion | To calculate wealth | All countries | Calculated | T = MIN(25, FOV/NDP) |
| $R_{t^*}$ | Rents ($) | To predict future rents | All countries | Calculated | $R_{t^*}$ = PRO * UNR |
| DCT | Discount rate | To calculate wealth | Global | Literature | None |
| WEA | Wealth ($) | | All countries | Calculated | $WEA = \sum_{t=t^*}^{t^*+T-1} \frac{R_t}{(1+DCT)^{t-t^*}}$ |

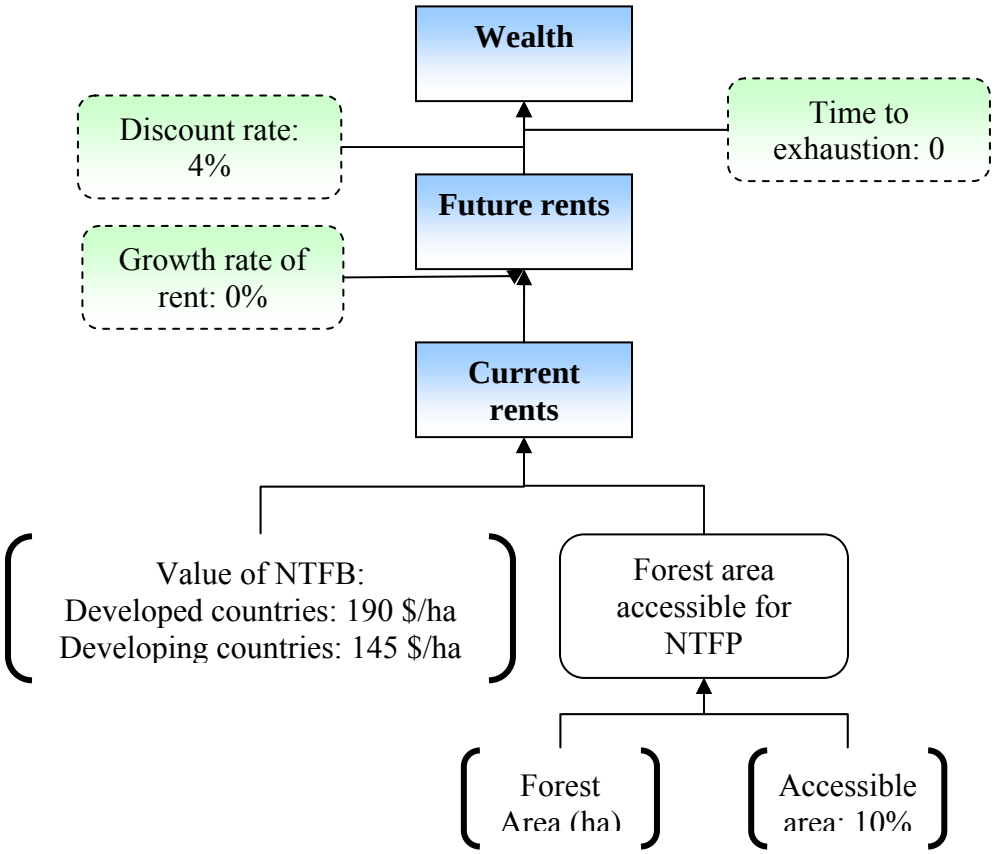
**Forest (non-timber forest assets)**

Timber revenues are not the only contribution forests make. Non-timber forest benefits such as minor forest products, hunting, recreation, watershed protection, options and existence values are significant benefits not explicitly accounted for. This leads to forest resources being undervalued.

A review of non-timber forest benefits in developed and developing countries reveals that returns per hectare per year from such benefits vary from $190 per hectare in developed countries to $145 per hectare in developing countries (based on Lampietti and Dixon, 1995 and Croitoru et al, 2003 and adjusted to 2000 prices).

Assuming that only one-tenth of the forest area in each country is accessible, this per hectare value is multiplied by one-tenth of the forest area in each country. Non-timber forest resources are then valued as the net present value of benefits over a time horizon of 25 years

*Figure 4: Non-timber forest wealth estimation - Flowchart*



## Cropland

Country level data on agricultural land prices are not widely published and available data is subject to distortions. We have therefore chosen to estimate land values based on the present discounted value of land rents, assuming that the products of the land are sold at world prices.

Highlights:

- Cropland rents for all countries are estimated using nine representative crops: maize, rice, wheat, bananas, grapes, apples, oranges, soybeans, coffee.
- The annual economic return to land is measured as a percentage of each crop's production revenue, otherwise known as the rental rate.
- Rental rates are obtained from a series of sector studies.
- The annual return in 2000 is projected to the year 2020 based on growth in production of 0.97 percent and 1.94 percent for developed and developing countries respectively (Rosengrant and others 1995).

*Figure 5: Cropland wealth estimation - Flowchart*

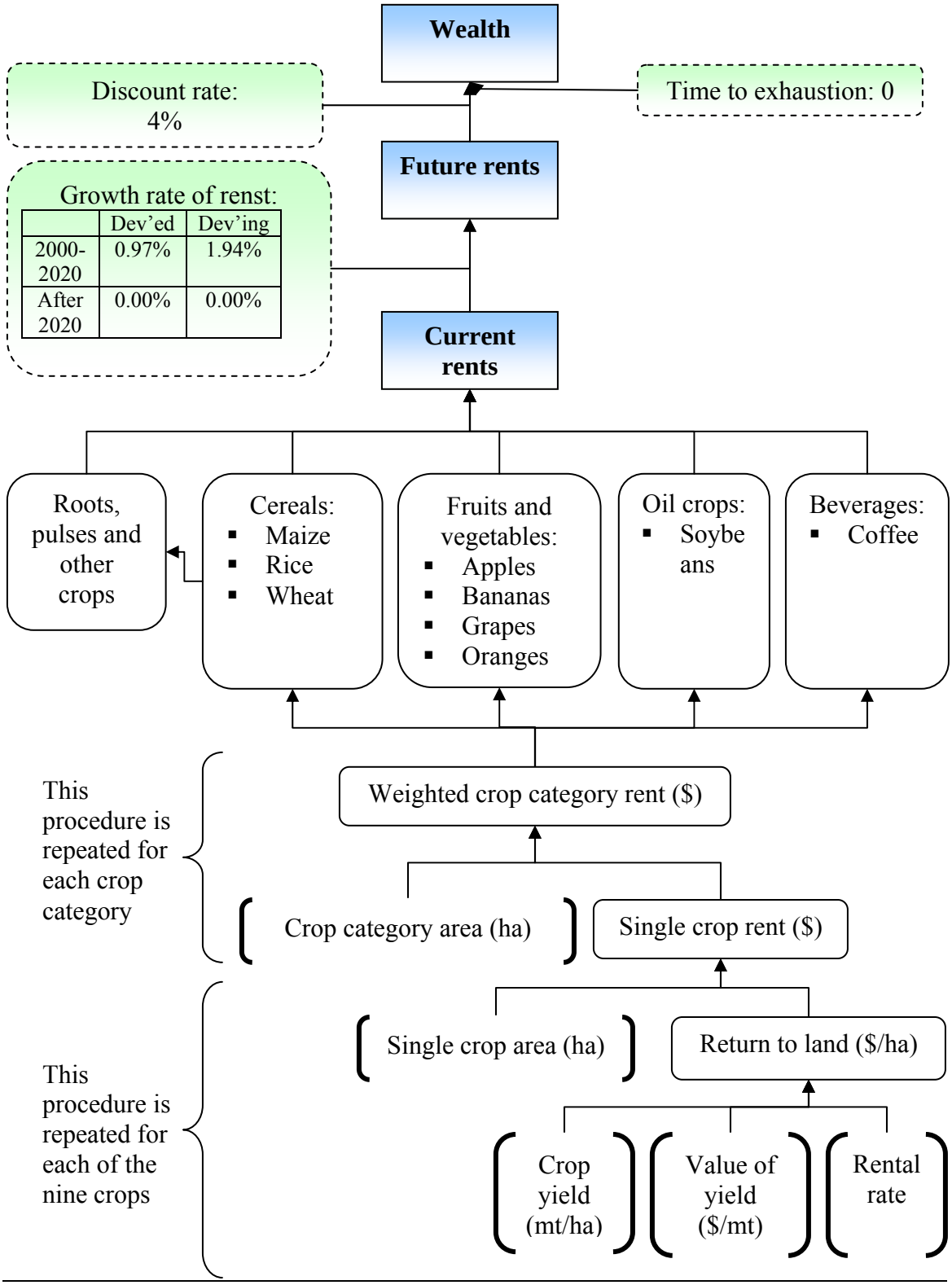


*Table 3. Cropland – Variables used and Sources*

| ***Code*** | ***Item*** | ***Use*** | ***Coverage*** | ***Sources*** | ***Formula*** |
|---|---|---|---|---|---|
| YIE | Crop yield (mt/ha) | To calculate return to land | All countries | FAO | None |
| PRI | Value of yield ($/mt) | To calculate return to land | Global | Various soruces | None |
| RRT | Rental rate | To calculate return to land | Selected countries | Sector reports | None |
| RET | Return to land | To calculate crop rents | All countries | Calculated | RET = YIE*PRI*RRT |
| CRA | Crop area | To calculate crop rents | All countries | FAO | None |
| CRE | Crop rent ($) | To calculate category rent | All countries | Calculated | CRE = CRA*RET |
| CCA | Crop category area (ha) | To calculate category rent | All countries | FAO | None |
| CCR | Crop category rent | To calculate rents | All countries | Calculated | $CCR = \sum_i \left( CRE_i * CCA_i \right)$ |
| $R_{t*}$ | Rents ($) | To predict future rents | All countries | Calculated | $R_t = \sum_n CCR_n$ |
| RTG | Assumed growth rate of rents | To predict future rents | Global | Literature | <table><tr><td></td><td>Dev'ed</td><td>Dev'ing</td></tr><tr><td>2000-2020</td><td>0.97%</td><td>1.94%</td></tr><tr><td>After 2020</td><td>0.00%</td><td>0.00%</td></tr></table> |
| $R_t$ | Future rents (Constant $) | To estimate wealth | All countries | Calculated | $R_t = R_{t*}\left(1+g\right)^{t*-t}$ |
| DCT | Discount rate | To calculate wealth | Global | Literature | None |
| WEA | Wealth ($) | | All countries | Calculated | $WEA = \sum_{t=t*}^{t*+T-1} \frac{R_t}{\left(1+DCT\right)^{t-t*}}$ |

## Pasture land

Highlights:

- Pasture land rents for all countries are estimated using four representative products: beef, lamb, milk and wool.
- The annual economic return to land is measured as a percentage of each crop's production revenue, otherwise known as the rental rate.
- Rental rates are assumed to be a fixed proportion of the value of output. The rental rate is assumed to be 45 percent.
- The annual return in 2000 is projected to the year 2020 based on growth in production of 0.89 percent and 2.95 percent for developed and developing countries respectively (Rosengrant and others 1995).

*Figure 6: Pasture land wealth estimation - Flowchart*

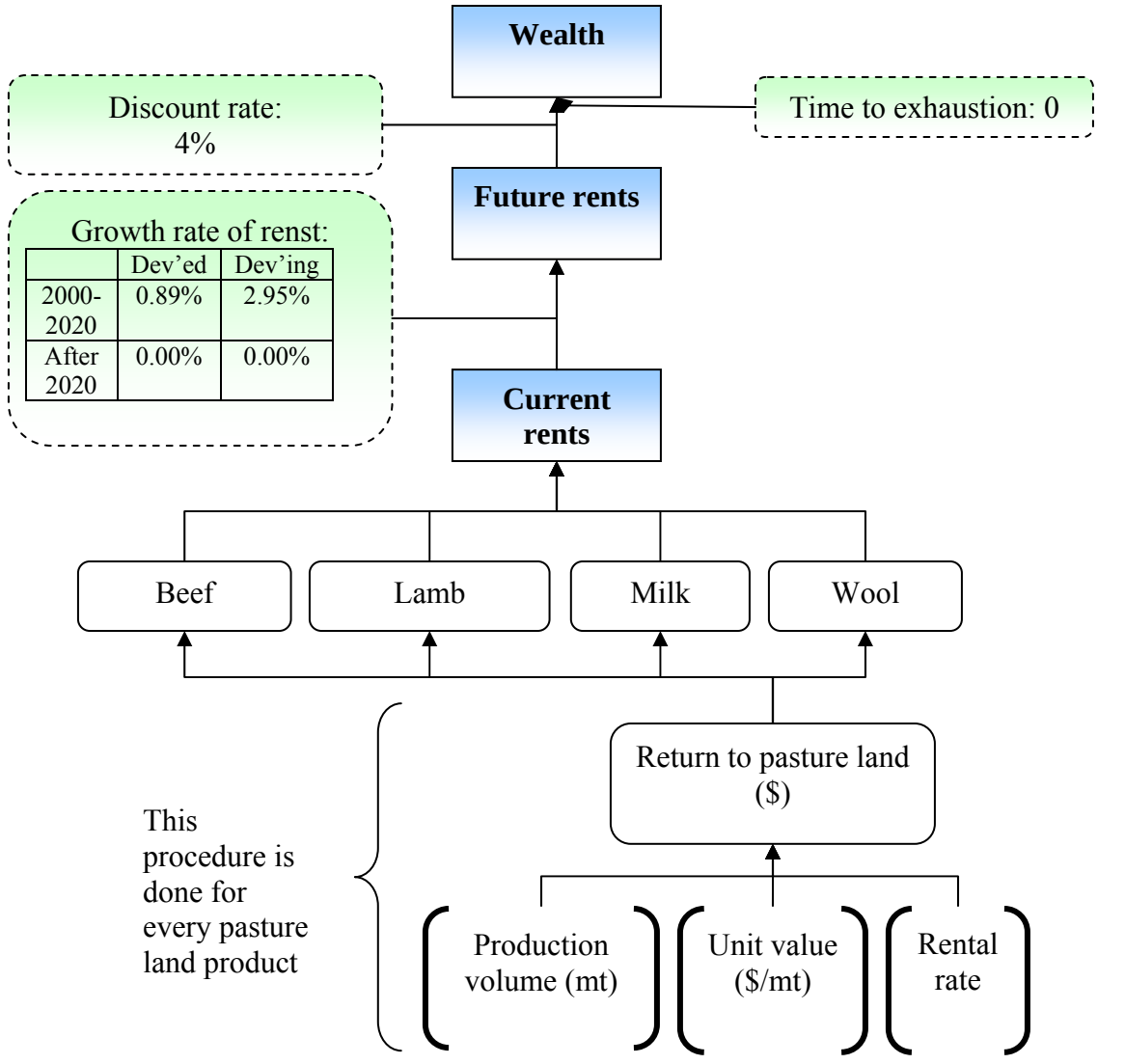


*Table 4. Pasture land wealth – Variables used and Sources*

| ***Code*** | ***Item*** | ***Use*** | ***Coverage*** | ***Sources*** | ***Formula*** |
|---|---|---|---|---|---|
| VOL | Production volume (mt) | To calculate return to land | All countries | FAO | None |
| PRI | Unit value of products ($/mt) | To calculate return to land | Global | Various soruces | None |
| RRT | Rental rate | To calculate return to land | Global | Assumed | None |
| RET | Return to land | To calculate crop rents | All countries | Calculated | RET = YIE*PRI*RRT |
| $R_{t*}$ | Rents ($) | To predict future rents | All countries | Calculated | $R_t = \sum_n RET_n$ |
| RTG | Assumed growth rate of rents | To predict future rents | Global | Literature | <table><tr><td></td><td>Dev'ed</td><td>Dev'ing</td></tr><tr><td>2000-2020</td><td>0.89%</td><td>2.95%</td></tr><tr><td>After 2020</td><td>0.00%</td><td>0.00%</td></tr></table> |
| $R_t$ | Future rents (Constant $) | To estimate wealth | All countries | Calculated | $R_t = R_{t^*}(1+g)^{t^*-t}$ |
| DCT | Discount rate | To calculate wealth | Global | Literature | None |
| WEA | Wealth ($) | | All countries | Calculated | $WEA = \sum_{t=t^*}^{t^*+T-1} \frac{R_t}{(1+DCT)^{t-t^*}}$ |

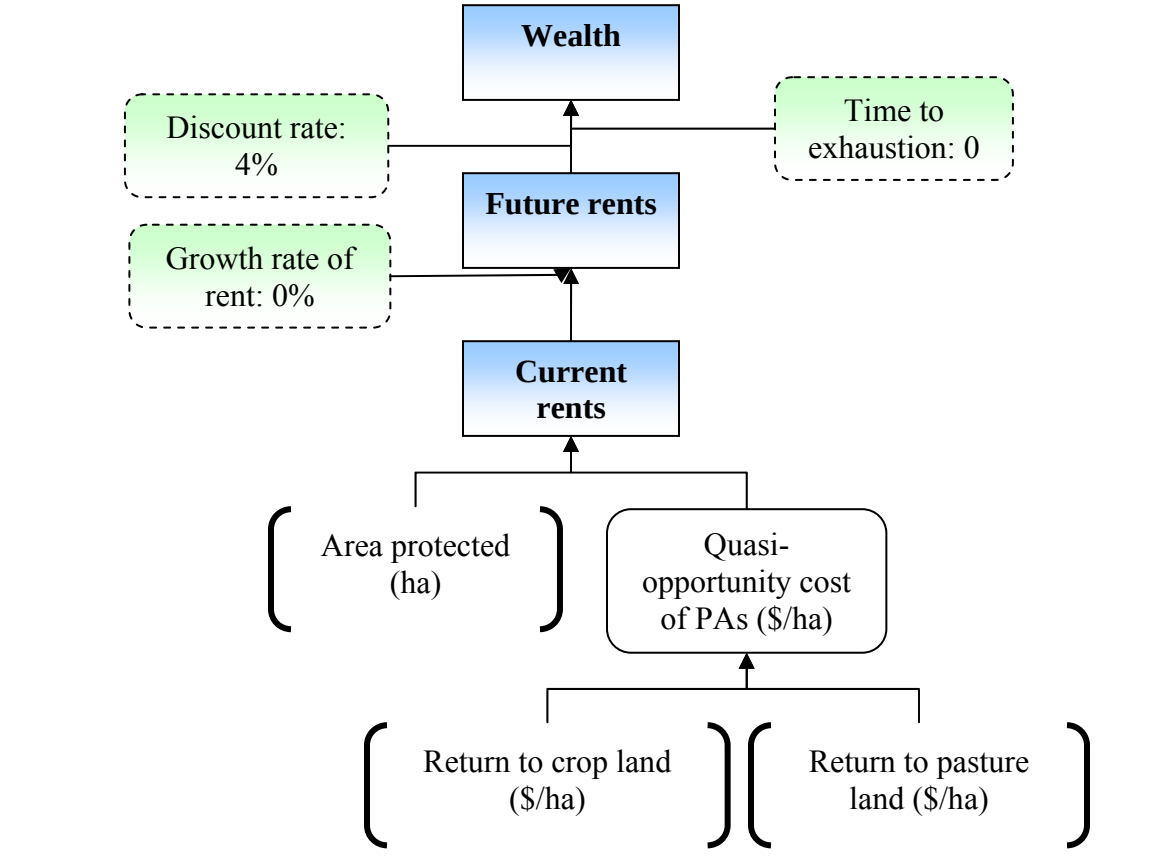
## Protected areas

Protected areas provide a number of benefits that range from existence values to recreational values. They can be a significant source of income from a thriving tourist industry. These values are revealed by a high willingness-to-pay for such benefits. The establishment and good maintenance of protected areas preserves an asset for the future and therefore protected areas form an important party of the natural capital estimates.

Protected areas (IUCN categories I-VI) are valued at the lower of per-hectare returns to pasture land and cropland – a quasi opportunity cost. These returns are capitalized over a 25-year time horizon, using a 4 percent discount rate. Limiting the value of protected areas to the opportunity cost of preservation probably captures the minimum value, but not the complete value, of protected areas.

Data on protected areas is taken from the World Database of Protected Areas which is compiled by UNEP-WCMC. Given the frequent revisions to the database, the data used is for 2003. In the cases of missing data on area protected, this was assumed to be zero.

*Figure 7: Protected areas wealth estimation - Flowchart*



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