# Accounting Ecological Capital for Adjusted Net Domestic Product

Dr saudamini Das,
Institute of Economic Growth, Delhi

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# Adjusting GDP for reproducible, human, natural and ecological capital

Conventional economic indicators

- GDP: market value of all final goods and services
- NDP: GDP minus depreciation of reproducible capital (consumption of fixed capital)

Adjusted NDP

- Adjustments for changes in human capital
- Adjustments for changes in natural capital (Net changes in renewable and non-renewable natural resource stocks)
- Adjustments for changes in **ecological capital**

*Ed Barbier (WCERE 2014, World Bank panel), Accounting for marsh creation in Louisiana, USA, in light of the 2012 Louisiana Coastal Master Plan.*

# Adjusted NDP

- Conventional NDP: accounts for the ‘depreciation’ in value of only reproducible capital.

- **Inclusive wealth approach:** changes in human, natural and ecological capital should be adjusted to determine whether current production in the economy is reliant on depreciating or adding to overall wealth. *(Dasgupta , 2009 and Arrow et al., 2012)*

- Current investments in education, training and health are likely to lead to net gains in human capital.

- Depletion of natural capital (net gain or loss), both non-renewable ( fossil fuels and minerals) and renewable (forests and fish) need to be adjusted.

- Ecological capital contribution - direct benefits provided by the current stock of ecosystems and **capital revaluation that occurs if ecosystems are converted to or restored from other land uses** also need to be accounted.

# Inclusive wealth and investment

$$W(t) = \gamma^{k} K(t) + \gamma^{H} H(t) + \gamma^{Z} Z(t) + \gamma^{N} N(t) + \gamma^{D} D(t)$$

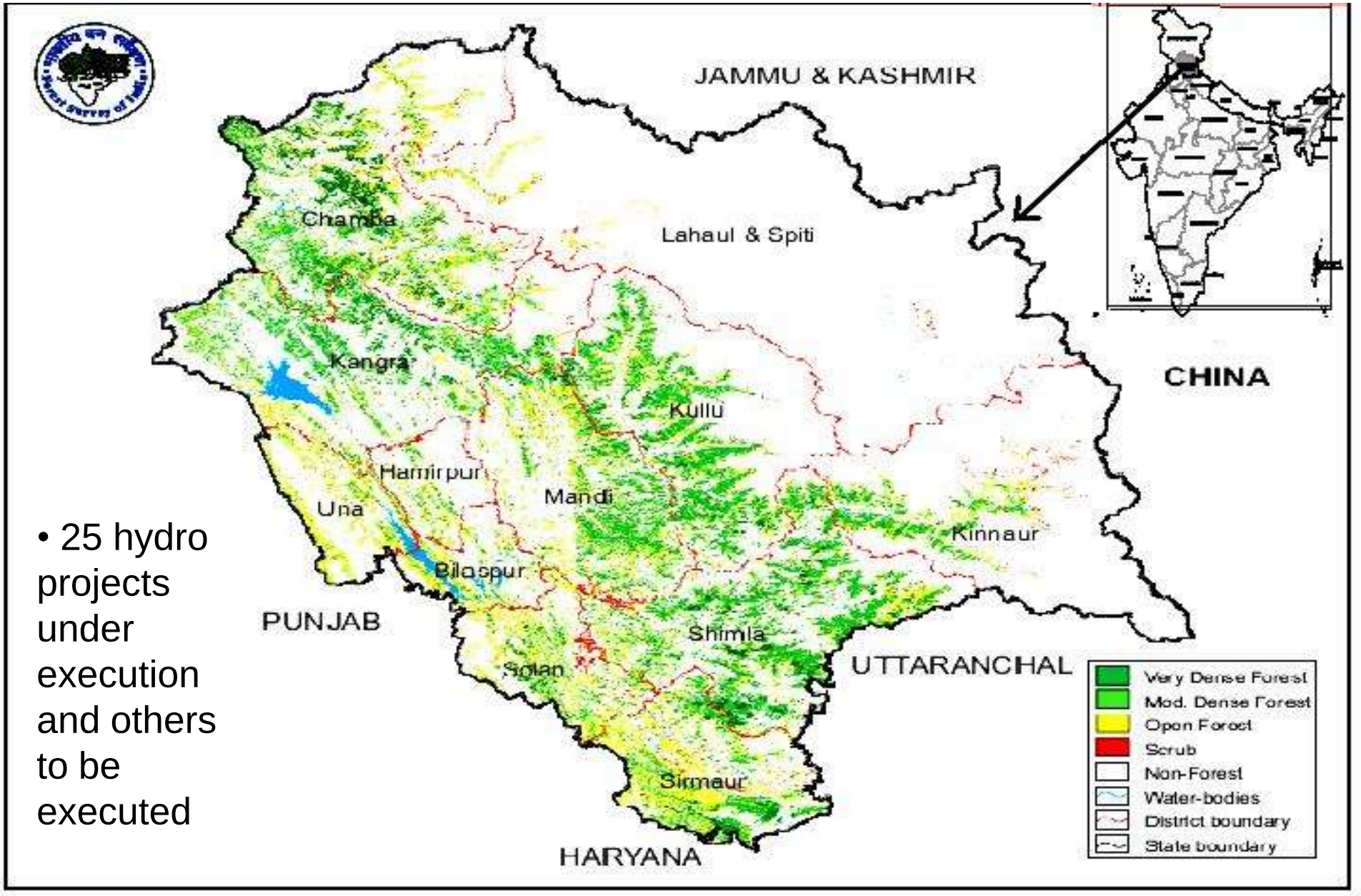
$$I(t) = \gamma^{k} \dot{K} + \gamma^{H} \dot{H} + \gamma^{Z} \dot{Z} + \gamma^{N} \dot{N} + \gamma^{D} \dot{D}$$

$$\dot{K} = {}^{\partial K(t)}\!/_{\partial t} = Y(t) - C(t) - wK(t) - E(t)$$

• Novel addition is change in direct and indirect benefits of ecosystems due to ecological restoration.

-- the value of the ***direct benefits*** *provided by the current stock of restored ecosystems*
-- present value of the **future *direct and indirect benefits*** *of ecosystems*

# The case study on hydro power from the State of Himachal Pradesh




- 25 hydro projects under execution and others to be executed

# Details of Power Projects under execution

| River Basin | Name of Project | Capacity (MW) | Type | Category |
|---|---|---|---|---|
| **River Yamuna Basin** | | | | |
| 1 | Sainj | 5.5 | ROR | B |
| 2 | Dhamwari Sunda | 70 | ROR | A |
| 3 | **Renuka Dam** | **40** | **Reservoir** | **A** |
| **River Satluj Basin** | | | | |
| 1 | Bhaba Aug P/House | 3 | ROR | B |
| 2 | Nathpa Jhakri | 1500 | ROR | A |
| 3 | Baspa Stage II | 300 | ROR | A |
| 4 | Karchham Wangtoo | 1000 | ROR | A |
| 5 | **Koldam** | **800** | **Reservoir** | **A** |
| 6 | Keshang Stage - 1 | 66 | ROR | A |
| **River Beas Basin** | | | | |
| 1 | Larji | 126 | ROR | A |
| 2 | Khauli | 12 | ROR | B |
| 3 | Parbati Stage II | 2051 | ROR | A |
| 4 | Neogal | 15 | ROR | B |
| 5 | Allian Dhugan | 192 | ROR | A |
| 6 | Patkari | 16 | ROR | B |
| 7 | Fozal | 6 | ROR | B |
| 8 | Uhl Stage III | 100 | ROR | A |
| **River Ravi Basin** | | | | |
| 1 | Holi | 3 | ROR | B |
| 2 | Chamera Stage II | 300 | ROR | A |
| 3 | Chamera Stage II | 231 | ROR | A |
| 4 | Bharmour | 45 | ROR | A |
| 5 | Budhil | 70 | ROR | A |
| 6 | Harsar | 60 | ROR | A |
| 7 | Kugti | 45 | ROR | A |
| 8 | Mini Micro(upto 3MW) | 101.59 | | |
| **Total of under Execution = 7059.14** | | | | |

**Forest land submerged per MW of power under**

1. **Run-Of-River (ROR) project: 0.114 ha**
2. **Reservoir project: 5.52 ha**

**Note: A, B, C are rankings of power projects as per its attractiveness as prepared by Central Electricity Authority of India**

# Hydel Power: Sectoral linkages

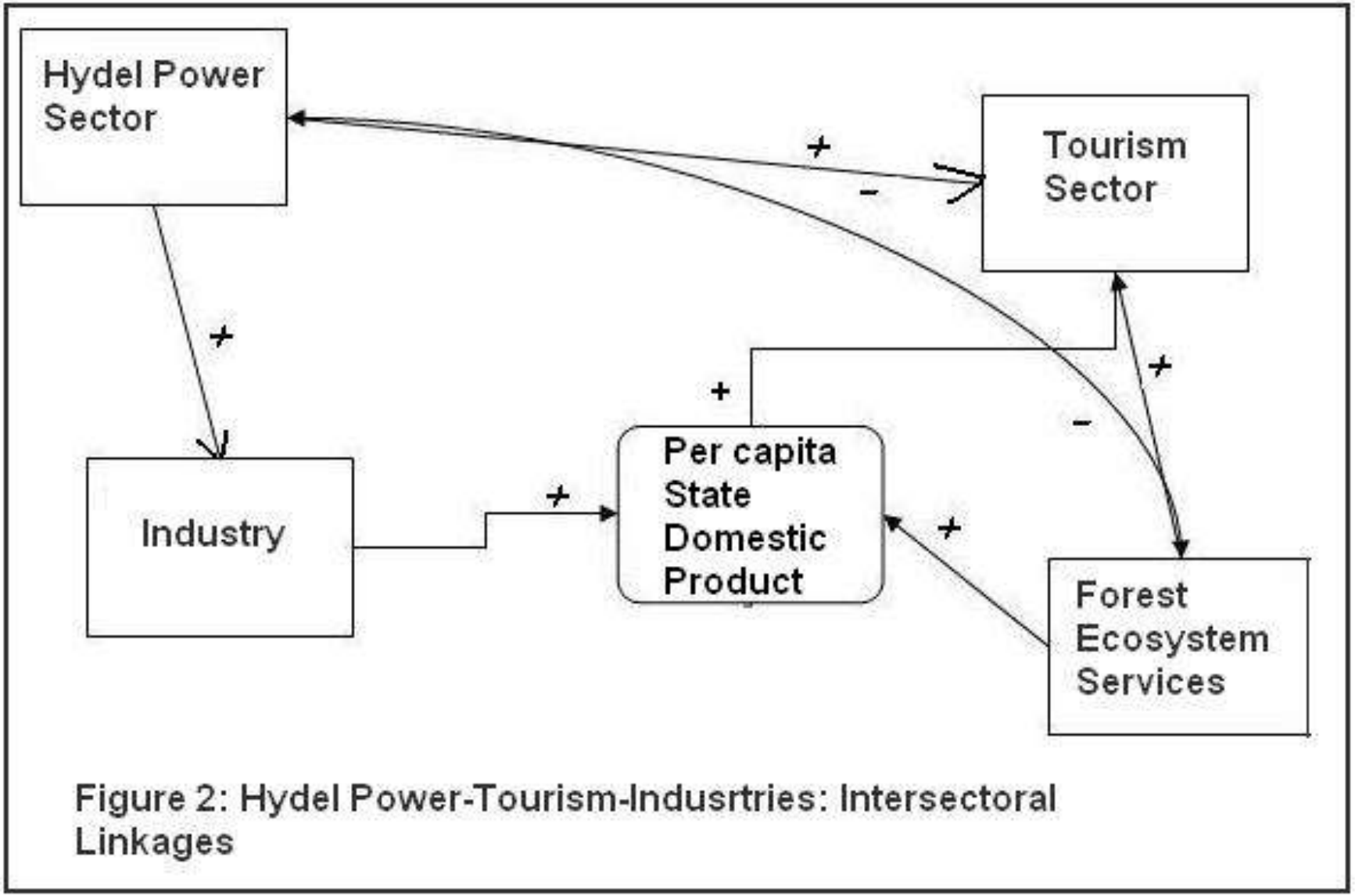



Figure 2: Hydel Power-Tourism-Indusrtries: Intersectoral Linkages

# Methodology

3 Sectors: Industries, Tourism and Forest (ESS)

$$V_I = f(I, E, P) \quad f_I, f_E, f_P > 0$$

$$V_T = g(R, P, F), F = q(P) \quad g_R, g_P, g_F > 0 \quad q_p < 0$$

$$E_{SS} = s(F) = s(q(P)) \quad s_F > 0 \quad s_P = s_q q_P < 0$$

2 Scenarios: REFSEN and SUSDEV

- REFSEN: Use past data to estimate parameters and extrapolate $V_I$ , $V_T$ $V_F$ (=$E_{SS}$) till 2030.

- SUSDEV: Assume 2 reservoir based plants to be dropped and measure impact on these sectors

# Change in income under SUSDEV

$$\Delta Y_P = \Delta V_{IP} + \Delta V_{TP} + \Delta E_{SSP} = f_P \Delta P + \{g_P \Delta P - g_q q_P \Delta P\} + s_q q_P \Delta P$$

$\Delta Y_P$ = change in SDP due to change in power supply

$f_P \Delta P$ = change in value added of industries,

$g_P \Delta P$ = direct effect of power on tourism income,

$g_q q_p \Delta P$ = indirect effect of power on tourism through change in forest area

$s_q q_P \Delta P$ = change in ecosystem services due to change in forest area because of power projects

# Results

$$Y_t = E_t^{0.54} I_{t-1}^{0.148} P_t^{0.631}$$ (Industries)

## State level estimates (Tourism)

| Variables/ Tourists | Total Tourists | Indian tourists | Foreign tourists |
|---|---|---|---|
| Commercial Power | 0.511** (2.49) | 0.46 (1.57) | 1.612*** (4.56) |
| Kilometres of roads | 1.05 ***(2.59) | 1.056** (2.38) | 1.32 **(2.48) |
| Dense Forest Area | 0.133 (0.31) | -0.187 (-0.44) | 0.33 (0.64) |
| Constant | -10.41* (-1.68) | -7.33 (-1.19) | -24.36*** (-3.31) |

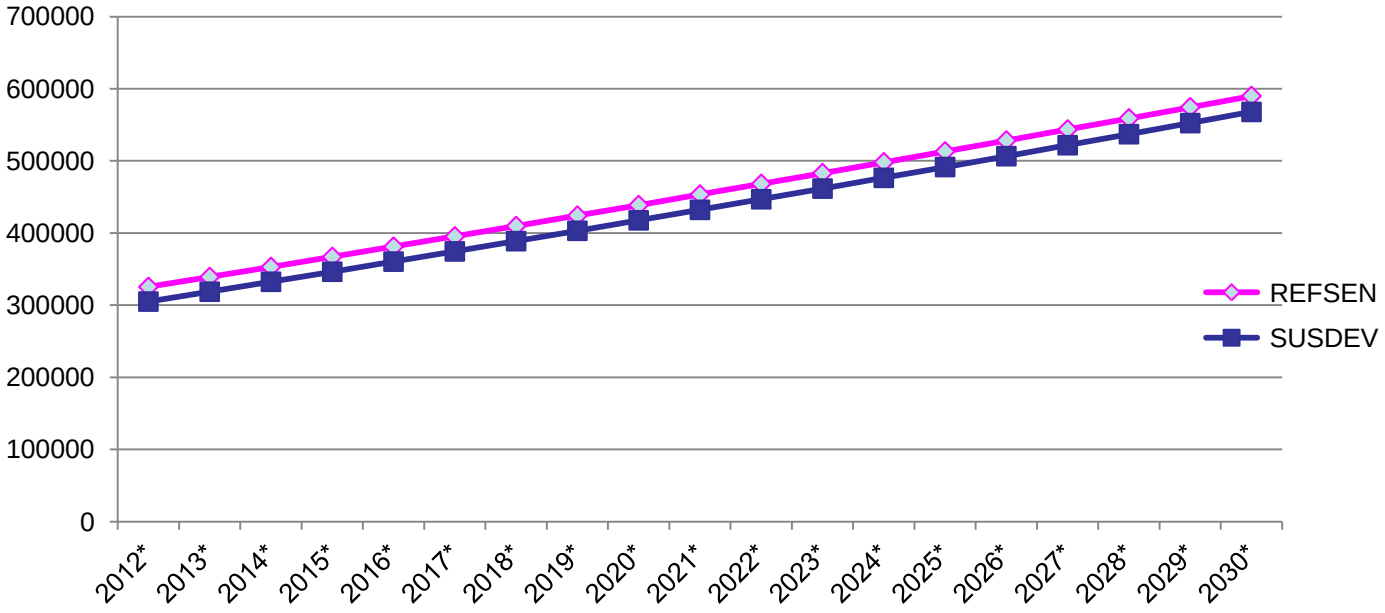
## District Level estimates (tourism)

| Variables/ Tourists | Total tourists | Indian tourists | Foreign tourists |
|---|---|---|---|
| Kilometres of Roads | 0.186 *(1.96) | 0.174 *(1.83) | 0.553*** (3.01) |
| Dense Forest Area | 0.545* (1.86) | 0.566* (1.94) | 0.196 (0.47) |
| Number of Parks and sanctuaries | 0.379*(1.88) | 0.361* (1.82) | 0.879 **(2.29) |
| No. of. Religious & Tourism Places | -0.102 (-0.36) | -0.120 (-0.42) | 0.216 (1.20) |

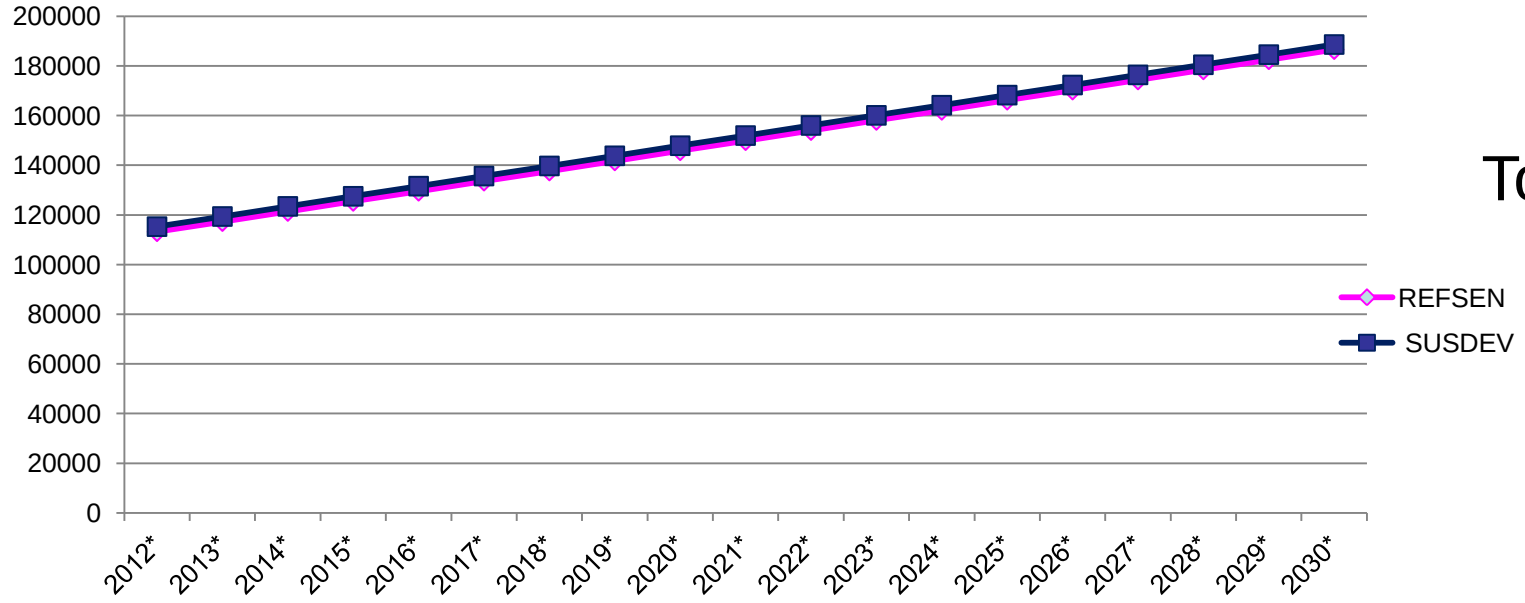
# Value added of Industry and Tourism sector

| | Industry Sector | | Tourism Sector | |
|---|---|---|---|---|
| Year | Fitted manufacturing and construction sector output (Rs lakhs) under REFSEN | Fitted manufacturing and construction sector output (Rs lakhs) under SUSDEV | Fitted income from tourism (Rs lakhs) under REFSEN | Fitted income from tourism (Rs lakhs) under SUSDEV |
| 2012 | 325232.78 | 304933.05 | 113224.35 | 115284.14 |
| 2013 | 339020.52 | 318613.05 | 117298.50 | 119358.29 |
| 2014 | 352924.34 | 332409.76 | 121372.64 | 123432.44 |
| 2015 | 366942.67 | 346321.65 | 125446.79 | 127506.58 |
| 2016 | 381073.98 | 360347.18 | 129520.94 | 131580.73 |
| 2017 | 395316.71 | 374484.84 | 133595.08 | 135654.87 |
| 2018 | 409669.38 | 388733.15 | 137669.23 | 139729.02 |
| 2019 | 424130.49 | 403090.63 | 141743.37 | 143803.16 |
| 2020 | 438698.61 | 417555.85 | 145817.52 | 147877.31 |
| 2021 | 453372.31 | 432127.39 | 149891.66 | 151951.46 |
| 2022 | 468150.21 | 446803.87 | 153965.81 | 156025.60 |
| 2023 | 483030.95 | 461583.96 | 158039.96 | 160099.75 |
| 2024 | 498013.23 | 476466.31 | 162114.10 | 164173.89 |
| 2025 | 513095.75 | 491449.65 | 166188.25 | 168248.04 |
| 2026 | 528277.25 | 506532.72 | 170262.39 | 172322.18 |
| 2027 | 543556.51 | 521714.30 | 174336.54 | 176396.33 |
| 2028 | 558932.34 | 536993.17 | 178410.68 | 180470.47 |
| 2029 | 574403.57 | 552368.17 | 182484.83 | 184544.62 |
| 2030 | 589969.06 | 567838.17 | 186558.98 | 188618.77 |

# Industries VA



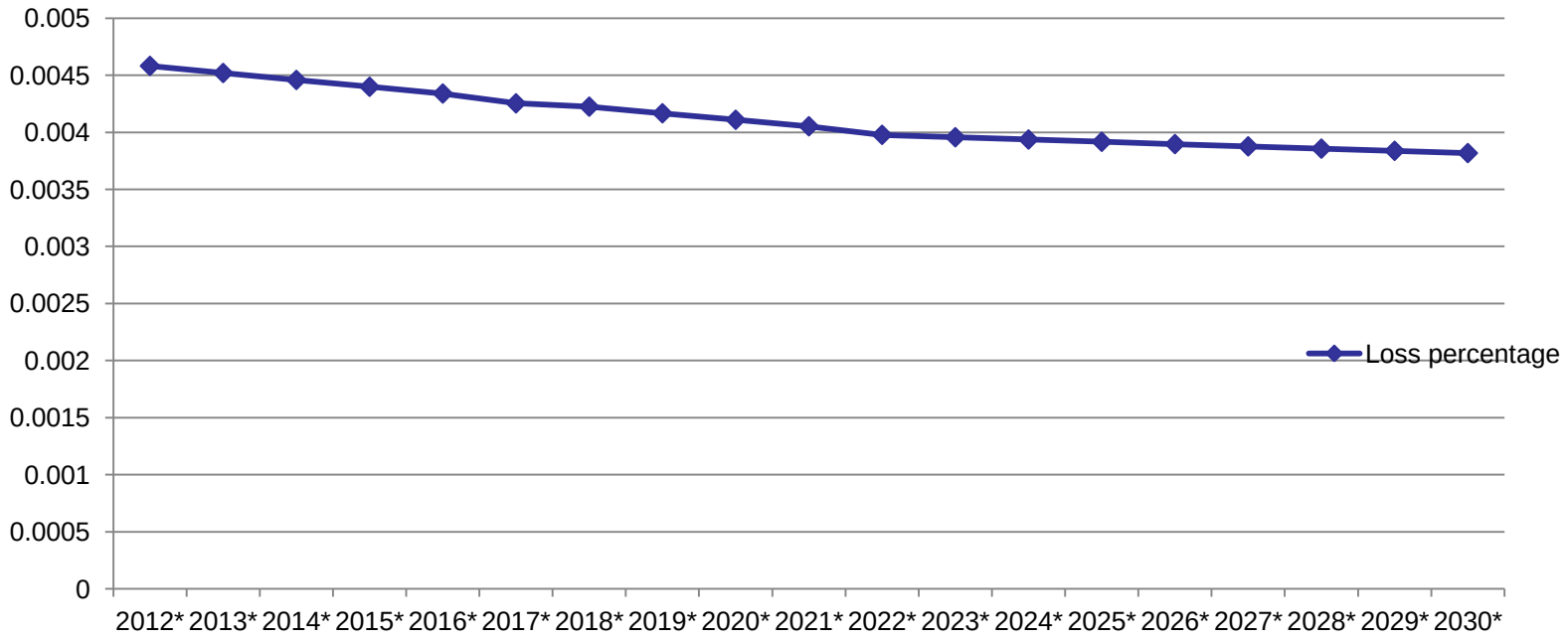

# Tourism VA



# Estimates of specific loss and gain

| Year | Loss in industry | Gain in tourism | Gain in ESS | Net loss | Projected REFSEN Net State Domestic Product | Loss percentage |
|---|---|---|---|---|---|---|
| 2012 | 20299.73 | 2059.79 | 13325.5 | 4914.44 | 1072508.27 | 0.004582 |
| 2013 | 20407.47 | 2059.79 | 13325.5 | 5022.18 | 1110993.48 | 0.004520 |
| 2014 | 20514.58 | 2059.79 | 13325.5 | 5129.29 | 1150330.09 | 0.004459 |
| 2015 | 20621.03 | 2059.79 | 13325.5 | 5235.74 | 1190123.95 | 0.004399 |
| 2016 | 20726.80 | 2059.79 | 13325.5 | 5341.51 | 1230622.53 | 0.004340 |
| 2017 | 20831.87 | 2059.79 | 13325.5 | 5446.58 | 1280433.76 | 0.004254 |
| 2018 | 20936.23 | 2059.79 | 13325.5 | 5550.94 | 1313896.69 | 0.004225 |
| 2019 | 21039.86 | 2059.79 | 13325.5 | 5654.57 | 1356964.97 | 0.004167 |
| 2020 | 21142.76 | 2059.79 | 13325.5 | 5757.47 | 1400715.01 | 0.004110 |
| 2021 | 21244.92 | 2059.79 | 13325.5 | 5859.63 | 1445815.22 | 0.004053 |
| 2022 | 21346.33 | 2059.79 | 13325.5 | 5961.04 | 1498684.11 | 0.003978 |
| 2023 | 21447.00 | 2059.79 | 13325.5 | 6061.71 | 1531828.36 | 0.003957 |
| 2024 | 21546.92 | 2059.79 | 13325.5 | 6161.63 | 1565079.79 | 0.003937 |
| 2025 | 21646.09 | 2059.79 | 13325.5 | 6260.80 | 1598436.48 | 0.003917 |
| 2026 | 21744.52 | 2059.79 | 13325.5 | 6359.23 | 1631896.58 | 0.003897 |
| 2027 | 21842.21 | 2059.79 | 13325.5 | 6456.92 | 1665458.29 | 0.003877 |
| 2028 | 21939.17 | 2059.79 | 13325.5 | 6553.88 | 1699119.91 | 0.003857 |
| 2029 | 22035.39 | 2059.79 | 13325.5 | 6650.10 | 1732879.79 | 0.003838 |
| 2030 | 22130.89 | 2059.79 | 13325.5 | 6745.60 | 1766736.39 | 0.003818 |

# Loss percentage



# Observations

• Preserving National Parks will male Hydro Power generation less stressful  to fragile ecosystem of the state.

•Preservation of National Parks is still economically justifiable as cost is a meager 0.0038% of projected SDP.

• Potential environmental cost will be further low as dd for recreational services is income elastic.

• It improves equity as poor and marginalized people are the beneficiaries

• The overarching objective of actualizing the hydro power potential in Himachal Pradesh should take serious note of these environmental concern.

# Restoring mangrove from other land uses (agricultural)

- Opportunity cost of protecting mangroves: -

  - Market value of land in coastal Kendrapada: Rs1, 72, 970 \ ha
  - Annual return (8%) from land: Rs13, 837 \ ha \ yr
  - (12%) : Rs20, 756 \ ha \ yr

- Benefit from retaining mangroves: -

  - Storm protection value (only for 3 damages): Rs1, 82, 080 \ ha
  - Annual Probability of VSCS and SC: 0.15 \ yr
  - Annual Storm Protection Value (3 damages): Rs27, 312 \ ha \ yr

Benefit > Cost

# Conclusion

- Ecologically fragile areas needs to differentially treated while considering developmental programs and conservation of natural capital should be given high priority.
- Accounting of ecological capital for any land use change needs to be measured.
- It is necessary to adjust value of ESS, especially recreational services of Ecological capital for income change (income elasticity $\approx$ 3.5)

THANKS