DAFTAR PUSTAKA


Malang, Kantor Wilayah Departemen Kehutanan Propinsi Jawa Timur, Malang.


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| Total        | 44 471 | 521 |

Sumber: Olahan data sekunder (Anonimous, 1996)

Lampiran 3. Tingkat Erosi, Luas Areal dan Jumlah Satuan Pengelolaan Lahan (SPL) di Wilayah Sub-Sub DAS Amprong
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|            |         | Tebu      | 16.7 | 203 | 2 |
|            | Tan. Semusim (D) | Jg-Sy | 32.6 | 1 187 | 12 |
|            |         | Jg-Jg-Sy | 19.8 | 932 | 8 |
|            |         | Jg-Jg-Ket.Phn | 37.3 | 466 | 1 |
|            |         | Tebu      | 17.4 | 579 | 7 |
| Kebun      | Penyanga (B) | Kopi | 3.2 | 53 | 1 |
| Pekarangan | Budidaya Thn. (C) | "pekarangan" | 209.3 | 33 | 1 |
|            |         | Tan. Semusim (D) | "pekarangan" | 172.1 | 145 | 6 |
| Tegal      | Budidaya Thn. (C) | Jg-Sy | 51.1 | 1 784 | 5 |
|            |         | Jg-Jg-Sy | 49.9 | 847 | 10 |
|            |         | Tebu      | 13.2 | 55 | 1 |
| Kebun      | Budidaya Thn. (C) | Kopi | 6.4 | 169 | 2 |
| Pekarangan | Budidaya Thn. (C) | "pekarangan" | 432.5 | 31 | 2 |
| Hutan      | Penyanga (B) | Apel | 4.8 | 14 | 1 |
|            | Budidaya Thn. (C) | Apel | 5.2 | 54 | 1 |
|            |         | Tebu | 34.9 | 25 | 1 |
|            |         | "hutan produksi" | 75.4 | 161 | 2 |
|            |         | "keraptn sedang" | 14.5 | 13 | 1 |
| Tegal      | Penyanga (B) | Tebu | 23.6 | 114 | 1 |
|            |         | Apel | 53.6 | 82 | 1 |
|            |         | "pekarangan" | 41.5 | 78 | 1 |
| Hutan      | Budidaya Thn. (C) | Jg-Jg-Sy | 134.5 | 199 | 3 |
|            | Lindung (A) | Apel | 64 | 146 | 1 |
|            |         | "hutan produksi" | 245.8 | 19 | 1 |
|            | Penyanga (B) | Jg-Jg-Sy | 88.75 | 33 | 2 |
|            |         | Tebu | 90.5 | 20 | 1 |
|            | Budidaya Thn. (C) | Jg-Jg-Sy | 49.3 | 304 | 1 |
|            |         | "hutan produksi" | 99.6 | 252 | 2 |
|            |         | "keraptn sedang" | 38 | 155 | 1 |
| Hutan      | Lindung (A) | Apel | 19 | 74 | 1 |
|            |         | Jg-Jg-Sy | 125.2 | 385 | 3 |
|            |         | "tdk terganggu" | 2.8 | 9 860 | 7 |
|            | Penyanga (B) | Jg-Jg-Sy | 184.6 | 137 | 2 |
|            |         | "hutan produksi" | 52.2 | 3 819 | 4 |

Lampiran 4. Tingkat Erosi, Luas Areal dan Jumlah Satuan Pengelolaan Lahan (SPL) di Wilayah Sub-Sub DAS Lesti
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Sumber: Olahan data sekunder (Anonimous, 1996)
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<td>41.93</td>
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<td>57.05</td>
<td>56.79</td>
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<td>48.58</td>
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<td>338610.95</td>
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Sumber: PERUM Jasa Tirta I (2002a dan 2002b)
Keterangan: *) keandalan debit 65%

<table>
<thead>
<tr>
<th>Pendugaan</th>
<th>Variabel 1</th>
<th>Variabel 2</th>
<th>Nilai</th>
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<tbody>
<tr>
<td>1. Harga air untuk :</td>
<td>HKp : harga komoditas padi (Rp 1 085 000 /ha)</td>
<td>AI : kebutuhan air/Ha (15 000 m³/ha) (kebutuhan 110 hari @ 136 m³)</td>
<td>HI = Rp 42.96/m³</td>
</tr>
<tr>
<td>a. Pengairan (HI)</td>
<td>Ytp/Yp : rasio produktivitas padi dg pengairan &amp; tanpa pengairan (diproksi dg. Rasio produktivitas padi sawah &amp; tegal : 35 005/58 9365 = 0.59 = 59%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Industri</td>
<td>RPMb : rasio debit outflow bulanan untuk pengairan/irigasi terhadap debit inflow bulanan bendung Mrican</td>
<td>RSMb : rasio debit outflow bulanan untuk industri terhadap debit inflow bulanan bendung Mrican</td>
<td>Shp = ( \frac{1}{12} \sum RPMb ) = 0,2875 = 28.75%</td>
</tr>
<tr>
<td>Sumbangan outflow Sutami terhadap :</td>
<td></td>
<td></td>
<td>Shm = ( \frac{1}{12} \sum RIMb ) = 0,0206 = 2.06%</td>
</tr>
<tr>
<td>a. Pengairan (Shp)</td>
<td>RIMb : rasio debit outflow bulanan untuk industri terhadap debit inflow bulanan bendung Mrican</td>
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<td>b. Industri (Shm)</td>
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<td>2. Sumbangan outflow Sutami terhadap :</td>
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<td></td>
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<tr>
<td>a. Pengairan (Shp)</td>
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<tr>
<td>b. Industri (Shm)</td>
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</tr>
<tr>
<td>3. Debit inflow dari sungai</td>
<td></td>
<td></td>
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<tr>
<td>a. Bango (VIA1)</td>
<td>DM : rata-rata debit inflow bulanan dari Metro tahun 2002/2003 (15.11 m³/det)</td>
<td>VIA1 = DM</td>
<td></td>
</tr>
<tr>
<td>b. Sumber Brantas (VIA2)</td>
<td>LWM : luas wilayah catchment Sub-sub DAS Metro (33 338 ha)</td>
<td>VIA2 = 12.20 m³/det</td>
<td></td>
</tr>
<tr>
<td>c. Amprong (VIA3)</td>
<td>LWS2 : luas wilayah Sub-sub DAS Bango (25 234 ha)</td>
<td>VIA3 = 9.05 m³/det</td>
<td></td>
</tr>
<tr>
<td>d. Lesti (VIA4)</td>
<td>LWS3 : luas wilayah Sub-sub DAS Sumber Brantas (66 509 ha)</td>
<td>VIA4 = 16.05 m³/det</td>
<td></td>
</tr>
<tr>
<td>e. Metro (VIA M)</td>
<td>LWS4 : luas wilayah Sub-sub DAS Lesti (87 486 ha)</td>
<td>VIA M = DM</td>
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</tr>
<tr>
<td></td>
<td>DI : rata-rata debit inflow bulanan waduk Sengguruh tahun 2002/2003 (41.93 m³/det)</td>
<td>VIA1 = 4.63 m³/det</td>
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<tr>
<td></td>
<td>LWS : luas wilayah catchment Sengguruh (228 551 ha)</td>
<td>VIA2 = 12.20 m³/det</td>
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<tr>
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<td>LWS1 : luas wilayah Sub-sub DAS Bango (25 234 ha)</td>
<td>VIA3 = 9.05 m³/det</td>
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<tr>
<td></td>
<td>LWS2 : luas wilayah Sub-sub DAS Sumber Brantas (66 509 ha)</td>
<td>VIA4 = 16.05 m³/det</td>
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<tr>
<td></td>
<td>LWS3 : luas wilayah Sub-sub DAS Amprong (49 322 ha)</td>
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</table>
Lampiran 7. Lanjutan

<table>
<thead>
<tr>
<th>Pendugaan</th>
<th>Variabel 1</th>
<th>Variabel 2</th>
<th>Nilai</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Sumbangan lahan thd. volume <em>inflow</em> dari Sub-Sub DAS:</td>
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<td></td>
<td></td>
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<tr>
<td>Bango (ds₁)</td>
<td>fp : faktor pengali konversi debit (m³/det) menjadi volume m³ = 31 104 000 det (31.10 juta detik per tahun)</td>
<td>DSₖ(m³/det)/LWSₖ(ha)</td>
<td>dₛₖ = fp (det)• VIAₖ(m³/det)/LWSₖₘ(ha)</td>
</tr>
<tr>
<td>Sumber Brantas (ds₂)</td>
<td></td>
<td>ds₁ = 0.00570668 • 10⁶ m³/ha/th</td>
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</tr>
<tr>
<td>Amprong (ds₃)</td>
<td></td>
<td>ds₂ = 0.00570668 • 10⁶ m³/ha/th</td>
<td></td>
</tr>
<tr>
<td>Lesti (ds₄)</td>
<td></td>
<td>ds₃ = 0.00570668 • 10⁶ m³/ha/th</td>
<td></td>
</tr>
<tr>
<td>Metro (ds₅)</td>
<td></td>
<td>ds₄ = 0.00570668 • 10⁶ m³/ha/th</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ds₅ = fp (det)• VIA₅(m³/det)/LWS₅ₘ(ha)</td>
<td>ds₅ = 0.014296 • 10⁶ m³/ha/th</td>
<td></td>
</tr>
<tr>
<td>5. koefisien penyesuaian volume sedimen (kp)</td>
<td>Massa sedimen dari hasil analisa erosi lahan (ton/th) * pada titik pemantauan:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Jembatan Pendem (78 337.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gadang (551 673.61)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Tawang rejeni (268 542.82)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dari hasil analisa transportasi sedimen (ton/th) * pada titik pemantauan:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. Jembatan Pendem (82 831.65)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Gadang (472 154.83)</td>
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<td></td>
</tr>
<tr>
<td>3. Tawang rejeni (116 513.78)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rasio 1 = 82 831.65/78,337.70 = 1.06</td>
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<td></td>
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<tr>
<td>Rasio 2 = 472 154.83/551 673.61 = 0.86</td>
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<td></td>
<td></td>
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<tr>
<td>Rasio 3 = 116 513.78/268 542.82 = 0.43</td>
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<tr>
<td>kp = Rata-rata rasio = 0.78</td>
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Lampiran 8. Konsep Penentuan Keseimbangan Waduk Sebagai Kendala Transisi
Lampiran 9. Sketsa Mekanisme Arus Masuk, Arus Keluar dan Stok Air serta Sedimen

Waduk Sengguruh

Elevasi 292.50 m ≈ 2.32 juta m³
Elevasi 291.50 m ≈ 1.36 juta m³
Elevasi 286 m ≈ 0.32 juta m³

Waduk Sutami

Elevasi 272.50 m ≈ 175.61 juta m³
Elevasi 246.00 m ≈ 90 juta m³
29.49 juta m³
60.51 juta m³

Keterangan :

$V_{kap}$ : kapasitas waduk
$V_{m}^{air}$ : volume air masuk
$V_{m}^{sedm}$ : volume sedimen masuk
$V_{S}^{air}$ : volume stok air
$V_{S}^{sedm}$ : volume stok sedimen
$V_{air}^{m}$ : volume air keluar = 31.53 * $W_{o}$
Lampiran 10. Lokasi Pengumpulan Data Primer dan Jumlah Responden

<table>
<thead>
<tr>
<th>Sub-DPS</th>
<th>Kecamatan</th>
<th>Desa</th>
<th>Jumlah Responden</th>
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<td>Sumber Brantas</td>
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<td>Tulungrejo</td>
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<td>Sumbergondo</td>
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<tr>
<td></td>
<td>Junrejo</td>
<td>Mojorejo</td>
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<tr>
<td>Metro</td>
<td>Dau</td>
<td>Tegal Weru</td>
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<td>Petungsewu</td>
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<td>Selorejo</td>
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<td>Genteng</td>
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<td>Bumirejo</td>
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<td>Total Responden</td>
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Lampiran 11. Rincian Rumusan Fungsi Tujuan dan Kendala pada Perumusan Program Optimasi Dinamik DTA Sengguruh-Sutami

<table>
<thead>
<tr>
<th>Komponen</th>
<th>Rumus</th>
<th>Variabel</th>
</tr>
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<tbody>
<tr>
<td>Sawah kemiringan I (4 paket polatanam)</td>
<td>[\sum \ p_{1j} \cdot \text{X}<em>{1j}(t) ] + [\sum \ p</em>{2j} \cdot \text{X}<em>{2j}(t) ] + [\sum \ p</em>{3j} \cdot \text{X}<em>{3j}(t) ] + [\sum \ p</em>{4j} \cdot \text{X}_{4j}(t) ]</td>
<td>(Sd_{1j}(t))</td>
</tr>
<tr>
<td>Kebun kemiringan I (4 paket polatanam)</td>
<td>[\sum \ p_{1j} \cdot \text{X}<em>{1j}(t) ] + [\sum \ p</em>{2j} \cdot \text{X}<em>{2j}(t) ] + [\sum \ p</em>{3j} \cdot \text{X}<em>{3j}(t) ] + [\sum \ p</em>{4j} \cdot \text{X}_{4j}(t) ]</td>
<td>(Sd_{2j}(t))</td>
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<tr>
<td>Tegal kemiringan I (4 paket polatanam)</td>
<td>[\sum \ p_{1j} \cdot \text{X}<em>{1j}(t) ] + [\sum \ p</em>{2j} \cdot \text{X}<em>{2j}(t) ] + [\sum \ p</em>{3j} \cdot \text{X}<em>{3j}(t) ] + [\sum \ p</em>{4j} \cdot \text{X}_{4j}(t) ]</td>
<td>(Sd_{3j}(t))</td>
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<tr>
<td>Kebun kemiringan II (4 paket polatanam)</td>
<td>[\sum \ p_{1j} \cdot \text{X}<em>{1j}(t) ] + [\sum \ p</em>{2j} \cdot \text{X}<em>{2j}(t) ] + [\sum \ p</em>{3j} \cdot \text{X}<em>{3j}(t) ] + [\sum \ p</em>{4j} \cdot \text{X}_{4j}(t) ]</td>
<td>(Sd_{4j}(t))</td>
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1. Pendapatan usahatani
2. Manfaat air untuk listrik
3. Manfaat air untuk Pengairan Industri
4. Nilai stok akhir time horizon
5. Biaya pengerukan
Lampiran 11. Lanjutan

<table>
<thead>
<tr>
<th>Komponen</th>
<th>Rumus</th>
<th>Variabel</th>
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<tr>
<td><strong>B. Kendala :</strong></td>
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<tr>
<td><strong>1. Ketebalan tanah</strong></td>
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<td>Sawah kemiringan I (4 paket polatanam) :</td>
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<tr>
<td>$S_{d11k}(t+1) = S_{d11k}(t) - e_{11}/150$</td>
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<tr>
<td>$S_{d12k}(t+1) = S_{d12k}(t) - e_{12}/150$</td>
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<td>$S_{d14k}(t+1) = S_{d14k}(t) - e_{14}/150$</td>
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<td>Sawah kemiringan II (4 paket polatanam) :</td>
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<td>$S_{d26k}(t+1) = S_{d26k}(t) - e_{26}/150$</td>
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<td>$S_{d27k}(t+1) = S_{d27k}(t) - e_{27}/150$</td>
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<td>$S_{d28k}(t+1) = S_{d28k}(t) - e_{28}/150$</td>
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<td>Tegal kemiringan I (4 paket polatanam) :</td>
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<td>$S_{d39k}(t+1) = S_{d39k}(t) - e_{39}/150$</td>
<td>$S_{d39k}(t); e_{39}$</td>
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<td>$S_{d310k}(t+1) = S_{d310k}(t) - e_{310}/150$</td>
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<tr>
<td>$S_{d311k}(t+1) = S_{d311k}(t) - e_{311}/150$</td>
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<tr>
<td>$S_{d312k}(t+1) = S_{d312k}(t) - e_{312}/150$</td>
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<td>Tegal kemiringan II (5 paket polatanam) :</td>
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<td>$S_{d413k}(t+1) = S_{d413k}(t) - e_{413}/150$</td>
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<td>$S_{d414k}(t+1) = S_{d414k}(t) - e_{414}/150$</td>
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<tr>
<td>$S_{d415k}(t+1) = S_{d415k}(t) - e_{415}/150$</td>
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<tr>
<td>$S_{d416k}(t+1) = S_{d416k}(t) - e_{416}/150$</td>
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<tr>
<td>$S_{d417k}(t+1) = S_{d417k}(t) - e_{417}/150$</td>
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<tr>
<td>Kebun kemiringan I (4 paket polatanam) :</td>
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<tr>
<td>$S_{d518k}(t+1) = S_{d518k}(t) - e_{518}/150$</td>
<td>$S_{d518k}(t); e_{518}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d519k}(t+1) = S_{d519k}(t) - e_{519}/150$</td>
<td>$S_{d519k}(t); e_{519}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d520k}(t+1) = S_{d520k}(t) - e_{520}/150$</td>
<td>$S_{d520k}(t); e_{520}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d521k}(t+1) = S_{d521k}(t) - e_{521}/150$</td>
<td>$S_{d521k}(t); e_{521}$</td>
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</tr>
<tr>
<td>Kebun kemiringan II (4 paket polatanam) :</td>
<td></td>
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</tr>
<tr>
<td>$S_{d622k}(t+1) = S_{d622k}(t) - e_{622}/150$</td>
<td>$S_{d622k}(t); e_{622}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d623k}(t+1) = S_{d623k}(t) - e_{623}/150$</td>
<td>$S_{d623k}(t); e_{623}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d624k}(t+1) = S_{d624k}(t) - e_{624}/150$</td>
<td>$S_{d624k}(t); e_{624}$</td>
<td></td>
</tr>
<tr>
<td>$S_{d625k}(t+1) = S_{d625k}(t) - e_{625}/150$</td>
<td>$S_{d625k}(t); e_{625}$</td>
<td></td>
</tr>
<tr>
<td><strong>2. Air masuk :</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dari wilayah hulu Sengguruh</td>
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<td></td>
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<tr>
<td>Lahan non-budidaya intensif</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{ma1(t)}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{s1}(t) \cdot (L_{11}(t) + L_{21}(t) + L_{31}(t) + L_{41}(t)) +$</td>
<td>$d_{s1}; L_{11}(t)$</td>
<td></td>
</tr>
<tr>
<td>$d_{s2}(t) \cdot (L_{12}(t) + L_{22}(t) + L_{32}(t) + L_{42}(t)) +$</td>
<td>$d_{s2}; L_{12}(t)$</td>
<td></td>
</tr>
<tr>
<td>$d_{s3}(t) \cdot (L_{13}(t) + L_{23}(t) + L_{33}(t) + L_{43}(t)) +$</td>
<td>$d_{s3}; L_{13}(t)$</td>
<td></td>
</tr>
<tr>
<td>$d_{s4}(t) \cdot (L_{14}(t) + L_{24}(t) + L_{34}(t) + L_{44}(t)) +$</td>
<td>$d_{s4}; L_{14}(t)$</td>
<td></td>
</tr>
<tr>
<td>$d_{sk}; L_{sk}(t)$ (dsk: share lahan thdp inflow pada sub-sub DPS ke-k)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Keterangan : k (Sub-Sub DPS) = 1 (Bango); 2 (Sb. Brantas); 3 (Amprong); 4 (Lesti); dan 5 (Metro)
### Lampiran 11. Lanjutan

<table>
<thead>
<tr>
<th>Komponen</th>
<th>Rumus</th>
<th>Variabel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B. Kendala</strong> (lanjutan) :</td>
<td></td>
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</tr>
<tr>
<td>2. Air masuk :</td>
<td>Dari wilayah hulu Sengguruh</td>
<td></td>
</tr>
<tr>
<td>Lahan budidaya intensif</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$ds_1^* { X_{111}(t) + X_{121}(t) + X_{131}(t) + X_{141}(t) + X_{3101}(t) + X_{3111}(t) + X_{3121}(t) + X_{4131}(t) + X_{4141}(t) + X_{4151}(t) + X_{4161}(t) + X_{4171}(t) + X_{6221}(t) + X_{6231}(t) + X_{6241}(t) + X_{6251}(t) }$</td>
<td>$d_{s_1}; L(I_1(t)); X_{14}(t)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$k = 1, 2$</td>
</tr>
<tr>
<td></td>
<td>$ds_2^* { X_{112}(t) + X_{122}(t) + X_{132}(t) + X_{142}(t) + X_{3102}(t) + X_{3112}(t) + X_{3122}(t) + X_{4132}(t) + X_{4142}(t) + X_{4152}(t) + X_{4162}(t) + X_{4172}(t) + X_{6222}(t) + X_{6232}(t) + X_{6242}(t) + X_{6252}(t) }$</td>
<td>$d_{s_2}; L(I_2(t)); X_{14}(t)$</td>
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<tr>
<td></td>
<td>$ds_3^* { X_{113}(t) + X_{123}(t) + X_{133}(t) + X_{143}(t) + X_{3103}(t) + X_{3113}(t) + X_{3123}(t) + X_{4133}(t) + X_{4143}(t) + X_{4153}(t) + X_{4163}(t) + X_{4173}(t) + X_{6223}(t) + X_{6233}(t) + X_{6243}(t) + X_{6253}(t) }$</td>
<td>$d_{s_3}; L(I_3(t)); X_{14}(t)$</td>
</tr>
<tr>
<td></td>
<td>Vma$_1$(t) (lanjutan)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dari wilayah Sub-sub DPS Metro</td>
<td></td>
</tr>
<tr>
<td>$ds_5^* { L_{15}(t) + L_{25}(t) + L_{35}(t) + L_{45}(t) }$</td>
<td>$d_{s_5}; L(I_5(t)); X_{15}(t)$</td>
<td></td>
</tr>
<tr>
<td>$ds_5^* { X_{115}(t) + X_{125}(t) + X_{135}(t) + X_{145}(t) + X_{3105}(t) + X_{3115}(t) + X_{3125}(t) + X_{4135}(t) + X_{4145}(t) + X_{4155}(t) + X_{4165}(t) + X_{4175}(t) + X_{6225}(t) + X_{6235}(t) + X_{6245}(t) + X_{6255}(t) }$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sedimen masuk</td>
<td>Dari wilayah hulu Sengguruh</td>
<td></td>
</tr>
<tr>
<td>Lahan non-budidaya intensif</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VKS $= { SDR_1^* { L_{11}(t) + E_{11} + L_{21}(t) + E_{21} + L_{31}(t) + E_{31} + L_4(t) + E_{41} } + SDR_2^* { L_{12}(t) + E_{12} + L_{22}(t) + E_{22} + L_{32}(t) + E_{32} + L_{42}(t) + E_{42} } + SDR_3^* { L_{13}(t) + E_{13} + L_{23}(t) + E_{23} + L_{33}(t) + E_{33} + L_{43}(t) + E_{43} } + SDR_4^* { L_{14}(t) + E_{14} + L_{24}(t) + E_{24} + L_{34}(t) + E_{34} + L_{44}(t) + E_{44} } }$</td>
<td>$SDR_k^*; L(I_k(t)); E_{ij}$</td>
<td></td>
</tr>
<tr>
<td>VKS : konversi massa sedimen menjadi volume dalam juta m$^3$</td>
<td></td>
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</tbody>
</table>

**Keterangan :** k (Sub-Sub DPS) = 1 (Bango); 2 (Sb. Brantas); 3 (Amprong); 4 (Lesti); dan 5 (Metro)
Lampiran 11. Lanjutan

Rumus

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</tr>
<tr>
<td>3. Sedimen masuk</td>
<td></td>
</tr>
<tr>
<td>Lahan buddaya intensif</td>
<td></td>
</tr>
<tr>
<td>VKS *</td>
<td></td>
</tr>
<tr>
<td>SDR 1: (X_{111}(t) \ast e_{111} + X_{121}(t) \ast e_{121} + X_{131}(t) \ast e_{131} + X_{141}(t) \ast e_{141} + X_{251}(t) \ast e_{251} + X_{261}(t) \ast e_{261} + X_{271}(t) \ast e_{271} + X_{281}(t) \ast e_{281} + X_{391}(t) \ast e_{391} + X_{3101}(t) \ast e_{3101} + X_{3111}(t) \ast e_{3111} + X_{3121}(t) \ast e_{3121} + X_{4131}(t) \ast e_{4131} + X_{4141}(t) \ast e_{4141} + X_{4151}(t) \ast e_{4151} + X_{4161}(t) \ast e_{4161} + X_{4171}(t) \ast e_{4171} + X_{5181}(t) \ast e_{5181} + X_{5191}(t) \ast e_{5191} + X_{5201}(t) \ast e_{5201} + X_{5211}(t) \ast e_{5211} + X_{6221}(t) \ast e_{6221} + X_{6231}(t) \ast e_{6231} + X_{6241}(t) \ast e_{6241} + X_{6251}(t) \ast e_{6251} )</td>
<td></td>
</tr>
<tr>
<td>SDR 2: (X_{112}(t) \ast e_{112} + X_{122}(t) \ast e_{122} + X_{132}(t) \ast e_{132} + X_{142}(t) \ast e_{142} + X_{252}(t) \ast e_{252} + X_{262}(t) \ast e_{262} + X_{272}(t) \ast e_{272} + X_{282}(t) \ast e_{282} + X_{392}(t) \ast e_{392} + X_{3102}(t) \ast e_{3102} + X_{3112}(t) \ast e_{3112} + X_{3122}(t) \ast e_{3122} + X_{4132}(t) \ast e_{4132} + X_{4142}(t) \ast e_{4142} + X_{4152}(t) \ast e_{4152} + X_{4162}(t) \ast e_{4162} + X_{4172}(t) \ast e_{4172} + X_{5182}(t) \ast e_{5182} + X_{5192}(t) \ast e_{5192} + X_{5202}(t) \ast e_{5202} + X_{5212}(t) \ast e_{5212} + X_{6222}(t) \ast e_{6222} + X_{6232}(t) \ast e_{6232} + X_{6242}(t) \ast e_{6242} + X_{6252}(t) \ast e_{6252} )</td>
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</tr>
<tr>
<td>SDR 3: (X_{113}(t) \ast e_{113} + X_{123}(t) \ast e_{123} + X_{133}(t) \ast e_{133} + X_{143}(t) \ast e_{143} + X_{253}(t) \ast e_{253} + X_{263}(t) \ast e_{263} + X_{273}(t) \ast e_{273} + X_{283}(t) \ast e_{283} + X_{393}(t) \ast e_{393} + X_{3103}(t) \ast e_{3103} + X_{3113}(t) \ast e_{3113} + X_{3123}(t) \ast e_{3123} + X_{4133}(t) \ast e_{4133} + X_{4143}(t) \ast e_{4143} + X_{4153}(t) \ast e_{4153} + X_{4163}(t) \ast e_{4163} + X_{4173}(t) \ast e_{4173} + X_{5183}(t) \ast e_{5183} + X_{5193}(t) \ast e_{5193} + X_{5203}(t) \ast e_{5203} + X_{5213}(t) \ast e_{5213} + X_{6223}(t) \ast e_{6223} + X_{6233}(t) \ast e_{6233} + X_{6243}(t) \ast e_{6243} + X_{6253}(t) \ast e_{6253} )</td>
<td></td>
</tr>
<tr>
<td>SDR 4: (X_{114}(t) \ast e_{114} + X_{124}(t) \ast e_{124} + X_{134}(t) \ast e_{134} + X_{144}(t) \ast e_{144} + X_{254}(t) \ast e_{254} + X_{264}(t) \ast e_{264} + X_{274}(t) \ast e_{274} + X_{284}(t) \ast e_{284} + X_{394}(t) \ast e_{394} + X_{3104}(t) \ast e_{3104} + X_{3114}(t) \ast e_{3114} + X_{3124}(t) \ast e_{3124} + X_{4134}(t) \ast e_{4134} + X_{4144}(t) \ast e_{4144} + X_{4154}(t) \ast e_{4154} + X_{4164}(t) \ast e_{4164} + X_{4174}(t) \ast e_{4174} + X_{5184}(t) \ast e_{5184} + X_{5194}(t) \ast e_{5194} + X_{5204}(t) \ast e_{5204} + X_{5214}(t) \ast e_{5214} + X_{6224}(t) \ast e_{6224} + X_{6234}(t) \ast e_{6234} + X_{6244}(t) \ast e_{6244} + X_{6254}(t) \ast e_{6254} )</td>
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</tbody>
</table>

Keterangan : k (Sub-Sub DPS) = 1 (Bango); 2 (Sb. Brantas); 3 (Amprong); 4 (Lesti); dan 5 (Metro)
Lampiran 11. Lanjutan

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<th>Variabel</th>
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</thead>
<tbody>
<tr>
<td>B. Kendala (lanjutan) : 3. Sedimen masuk</td>
<td>Lahan budidaya intensif</td>
<td>Dari wilayah Sub-sub DPS Metro</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$VKS \times [SDR_e \times (L_{15}(t) \times E_{15} + L_{25}(t) \times E_{25} + L_{35}(t) \times E_{35} + L_{45}(t) \times E_{45} + X_{15}(t) \times e_{115} + X_{25}(t) \times e_{125} + X_{35}(t) \times e_{135} + X_{45}(t) \times e_{145} + X_{55}(t) \times e_{315} + X_{65}(t) \times e_{316} + X_{75}(t) \times e_{317} + X_{85}(t) \times e_{318} + X_{95}(t) \times e_{319} + X_{105}(t) \times e_{320} + X_{115}(t) \times e_{321} + X_{125}(t) \times e_{322} + X_{135}(t) \times e_{323})]$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDR_c; L_{15}(t); X_{15}(t); e_{115}</td>
</tr>
<tr>
<td></td>
<td>4. Kapasitas Waduk</td>
<td>Waduk Sengguruh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outflow terjadi di atas elevasi 292.50 meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{kp1}(t+1) \leq V_{sa1}(t) + V_{ma1}(t) - 31.53 \times W_{o1}(t) + V_{ms}(t) - V_{ks1}(t)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Terjadi pengerukan sedimen bila stok sedimen $&gt; 1.36$ jt m$^3$</td>
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<tr>
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<td></td>
<td>$1.36 \geq V_{sa1}(t) + 0.4 \times V_{ms}(t) - V_{ks1}(t)$</td>
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<tr>
<td></td>
<td></td>
<td>Vss(t); Vms(t); Vks(t)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vss(t) ; Vms(t)</td>
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<tr>
<td></td>
<td></td>
<td>Outflow terjadi antara elevasi 246 – 227.50 meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$90 \leq V_{sa2}(t) + 31.53 \times W_{o1}(t) + V_{ma2}(t) - 0.6 + 0.92 \times V_{ms}(t) - 0.92 \times V_{ms}(t)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$90 \leq V_{sa2}(t) + 0.6 + 0.92 \times V_{ms}(t)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vss(t); Vms(t); Vks(t)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vss(t) ; Vms(t)</td>
</tr>
<tr>
<td></td>
<td>5. Lahan tersedia</td>
<td>Sawah kemiringan I (4 paket polatanam) :</td>
</tr>
<tr>
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<td></td>
<td>$X_{114k}(t) + X_{129k}(t) + X_{134k}(t) + X_{149k}(t) = TL_{1k}$</td>
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<td></td>
<td>Sawah kemiringan II (4 paket polatanam) :</td>
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<tr>
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<td></td>
<td>$X_{215}(t) + X_{261}(t) + X_{271}(t) + X_{281}(t) = TL_{2k}$</td>
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<td></td>
<td>Tegal kemiringan I (4 paket polatanam) :</td>
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<tr>
<td></td>
<td></td>
<td>$X_{3181}(t) + X_{3131}(t) + X_{3111}(t) + X_{3121}(t)$</td>
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<td>Tegal kemiringan II (5 paket polatanam) :</td>
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<td>$X_{4131}(t) + X_{4341}(t) + X_{4311}(t) + X_{4321}(t) = TL_{4k}$</td>
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<td>Kebun kemiringan I (4 paket polatanam) :</td>
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<tr>
<td></td>
<td></td>
<td>$X_{5181}(t) + X_{5191}(t) + X_{5201}(t) + X_{5221}(t) = TL_{5k}$</td>
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<td>Kebun kemiringan II (4 paket polatanam) :</td>
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<td>$X_{6221}(t) + X_{6231}(t) + X_{6241}(t) + X_{6251}(t) = TL_{6k}$</td>
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<td>Keterangan : $k$ (Sub-Sub DPS) = 1 (Bango); 2 (Sb. Brantas); 3 (Amprong); 4 (Lesti) dan 5 (Metro)</td>
</tr>
</tbody>
</table>
Lampiran 12. Program Pemecahan Optimasi Dinamik Aplikasi Perangkat Lunak GAMS (General Algebraic Modeling System)

$TITLE MANAJEMEN LAHAN DAS WADUK SUTAMI SENGGURUH JAWA TIMUR-MODELDTA
$ONTEXT

--------------------------------------------------------------------------------------------------------------------
MODEL DINAMIK EKONOMI DAS BRANTAS HULU UNTUK SUMBERDAYA LAHAN
*** TINGKAT BUNGA 10 % & HARGA KONSTAN ***
--------------------------------------------------------------------------------------------------------------------

$OFFTEXT

SETS
  T  horizon waktu / 2003*2020/

* Kategori aktivitas komoditas/polatanam pd lahan budidaya intensif
    A  Aktivitas lhn sawah kemiringan I /1*4/
    B  Aktivitas lhn sawah kemiringan II /5*8/
    C  Aktivitas lhn tegal kemiringan I /9*12/
    D  Aktivitas lhn tegal kemiringan II /13*17/
    E  Aktivitas lhn kebun kemiringan I /18*21/
    F  Aktivitas lhn kebun kemiringan II /22*25/

SCALARS
  * Koefisien Tingkat Bunga
    BGA  Tingkat Bunga /0.10/

  * Koefisien regresi fs produksi PADI sawah kemiringan I (ton per ha)
    a01  intersep /2.42/
    b101 parameter slop1 /7.075476019/
    R01 koefisien soil depth /0.96/

  * Koefisien regresi fs produksi PADI sawah kemiringan II (ton per ha)
    a02  intersep /1.83/
    b102 parameter slop1 /7.075476019/
    R02 koefisien soil depth /0.96/

  * Koefisien regresi fs produksi PADI tegal kemiringan I (ton per ha)
    a03  intersep /2.42/
    b103 parameter slop1 /2.588826/
    R03 koefisien soil depth /0.96/

  * Koefisien regresi fs produksi PADI tegal kemiringan II (ton per ha)
    a04  intersep /0.86/
    b104 parameter slop1 /4.381857143/
    R04 parameter slop2 /0.96/

  * Koefisien regresi fs produksi JAGUNG sawah kemiringan I (ton per ha)
    a05  intersep /1.53/
    b105 parameter slop1 /2.5797/
    R05 parameter slop2 /0.96/

  * Koefisien regresi fs produksi JAGUNG sawah kemiringan II (ton per ha)
    a06  intersep /1.07/
    b106 parameter slop1 /2.5797/
    R06 parameter slop2 /0.96/

Lampiran 12. Lanjutan
* Koefisien regresi fs produksi JAGUNG tegal kemiringan I (ton per ha)
  a07  intersep /1.18/
  b107 parameter slop1 /3.293998571/
  R07  parameter slop2 /0.96/

* Koefisien regresi fs produksi JAGUNG tegal kemiringan II (ton per ha)
  a08  intersep /0.56/
  b108 parameter slop1 /3.293998571/
  R08  parameter slop2 /0.96/

* Koefisien regresi fs produksi Kac Tnh tegal kemiringan I (ton per ha)
  a09  intersep /1.05/
  b109 parameter slop1 /2.262714286/
  R09  parameter slop2 /0.97/

* Koefisien regresi fs produksi Kac Tnh tegal kemiringan II (ton per ha)
  a10  intersep /0.83/
  b110 parameter slop1 /1.68744/
  R10  parameter slop2 /0.97/

* Koefisien regresi fs produksi KUBIS sawah kemiringan I (ton per ha)
  a11  intersep /24.31/
  b111 parameter slop1 /32.47142857/
  R11  parameter slop2 /0.99/

* Koefisien regresi fs produksi KUBIS sawah kemiringan II (ton per ha)
  a12  intersep /19.45/
  b112 parameter slop1 /32.47142857/
  R12  parameter slop2 /0.99/

* Koefisien regresi fs produksi KUBIS tegal kemiringan I (ton per ha)
  a13  intersep /19.52/
  b113 parameter slop1 /31.39542857/
  R13  parameter slop2 /0.99/

* Koefisien regresi fs produksi KUBIS tegal kemiringan II (ton per ha)
  a14  intersep /11.34/
  b114 parameter slop1 /31.39542857/
  R14  parameter slop2 /0.99/

* Koefisien regresi fs produksi KENTANG tegal kemiringan I (ton per ha)
  a15  intersep /20.65/
  b115 parameter slop1 /31.39542857/
  R15  parameter slop2 /0.99/

* Koefisien regresi fs produksi KENTANG tegal kemiringan II (ton per ha)
  a16  intersep /15.4/
  b116 parameter slop1 /31.39542857/
  R16  parameter slop2 /0.99/

* Koefisien regresi fs produksi WORTEL tegal kemiringan I (ton per ha)
  a17  intersep /14.56/
  b117 parameter slop1 /34.84714286/
  R17  parameter slop2 /0.99/

Lampiran 12. Lanjutan

* Koefisien regresi fs produksi WORTEL tegal kemiringan II (ton per ha)
  a18  intersep /8.82/
b118 parameter slop1 /34.84714286/
R18 parameter slop2 /0.99/

* Koefisien regresi fs produksi TEBU sawah kemiringan I (ton per ha)
  a19 intersep /43.16/
  b119 parameter slop1 /73.80228571/
  R19 parameter slop2 /0.95/

* Koefisien regresi fs produksi TEBU sawah kemiringan II (ton per ha)
  a20 intersep /20.08/
  b120 parameter slop1 /70.72937/
  R20 parameter slop2 /0.95/

* Koefisien regresi fs produksi TEBU tegal kemiringan I (ton per ha)
  a21 intersep /24.45/
  b121 parameter slop1 /65.60997/
  R21 parameter slop2 /0.95/

* Koefisien regresi fs produksi TEBU tegal kemiringan II (ton per ha)
  a22 intersep /18.81/
  b122 parameter slop1 /65.60997/
  R22 parameter slop2 /0.95/

* Koefisien regresi fs produksi APEL tegal kemiringan II (ton per ha)
  a23 intersep /19.18/
  b123 parameter slop1 /21.61850857/
  R23 parameter slop2 /0.95/

* Koefisien regresi fs produksi JERUK sawah kemiringan II (ton per ha)
  a24 intersep /8.92/
  b124 parameter slop1 /21.89301/
  R24 parameter slop2 /0.95/

*KOEFSIEN Sediment Delevery Ratio (nisbah pelepasan sedimen):
  SDR1 Sediment Deliv Rt Bango /0.184609/
  SDR2 Sediment Deliv Rt Sub-DAS Sumber Brantas /0.281699/
  SDR3 Sediment Deliv Rt Sub-DAS Amrong /0.269819/
  SDR4 Sediment Deliv Rt Lesti /0.264748/
  SDR5 Sediment Deliv Rt Metro /0.291963/

* Sumbangan lahan terhadap volume inflow
  DS1 sumbangan lahan wil Bango thdp inflow SG ~ juta m³ per ha per th /0.0057/
  DS2 sumbangan lahan wil Sb Brantas thdp inflow SG ~ juta m³ per ha per th /0.0057/
  DS3 sumbangan lahan wil Amprong thdp inflow SG ~ juta m³ per ha per th /0.0057/
  DS4 sumbangan lahan wil Lesti thdp inflow SG ~ juta m³ per ha per th /0.0057/
  DS5 sumbangan lahan wil Metro thdp inflow SG ~ juta m³ per ha per th /0.014296/

Lampiran 12. Lanjutan

* Biaya sosial waduk
  BYPK biaya pengerukan sedimen Sengguruh ~ Rp per m³ /7517.233/

* Harga komoditas ~ juta Rp per ton
HPd  harga padi GKP  /1.07/
HJg  harga jagung Pipilan  /0.85/
HKc  harga kacang glondong kering /1.50/
HKu  harga kubis  /0.96/
HKn  harga kentang  /1.93/
HWr  harga wortel  /1.05/
HTb  harga tebu  /0.15/
HAp  harga apel  /2.09/
HJr  harga jeruk  /2.62/
HKo  harga kopi Ose  /4.31/

* Tingkat pertumbuhan harga komoditas
  RHkc tingkat perubahan harga kacang tanah/0.0868/
  RHKu tingkat perubahan harga kubis  /0.0625/
  RHKn tingkat perubahan harga kentang  /0.1229/
  RHWr tingkat perubahan harga wortel  /0.10/

* Harga energi listrik dan air baku
  PE1 harga listrik di PLTA Sengguruh ~ Rp per kWh /402/
  PE2 harga listrik di PLTA Sutami ~ Rp per kWh /131.8/
  PI nilai air baku untuk pengairan ~ Rp per m$^3$ /42.96/
  PM nilai air baku untuk industri ~ Rp per m$^3$ /60/

* Faktor konversi tk erosi menjadi lapisan tanah yg hilang
  FKL faktor konversi ketebalan lapisan tanah /150/

* Variabel konversi volume sedimen
  KK koefisien konversi dr massa ke volume sedimen ~ ton per m$^3$ /0.9463924973/
  CV1 faktor konversi dari volume harian ke debit /8640/
  CV2 faktor konversi dari volume tahunan ke debit /31536000/
  KP koef penyesuaian vol sedimen potensial ke aktual /0.78/

PARAMETERS
* Harga komoditas lahan kebun ~ juta Rp
  HK(E) kebun kemiringan I
    /18  0.15,  19  2.09,  20  2.62,  21  4.31/  
  HC(F) kebun kemiringan II
    /22  0.15,  23  2.09,  24  2.62,  25  4.31/  

* Koefisien regresi fs produksi komoditas lahan kebun kemiringan I ~ ton per ha
  a25(E) intersep
    /18  24.45,  19  24.12,  20  9.92,  21  0.53/  
  b125(E) parameter slop1
    /18 65.60997,  19  21.61851,  20  16.39301,  21  1.25952/  
  R25(E) parameter slop2
    /18*21 0.95/  

* Koefisien regresi fs produksi komoditas lahan kebun kemiringan II (ton per ha)
  a26(F) intersep
    /22  18.81,  23  26.01,  24  10.73,  25  0.32/  

Lampiran 12. Lanjutan

* TINGKAT EROSI lahan budidaya intensif
<table>
<thead>
<tr>
<th>Sub-sub DAS Bango</th>
<th>tk erosi lahan sawah kemiringan I ~ ton per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>ea1(A)</td>
<td>0.5, 2 0.5, 3 0.6, 4 6.1</td>
</tr>
<tr>
<td>eb1(B)</td>
<td>5 100, 6 100, 7 100, 8 100</td>
</tr>
<tr>
<td>ec1(C)</td>
<td>9 45.8, 10 46.2, 11 46.06</td>
</tr>
<tr>
<td>ed1(D)</td>
<td>12 7.07</td>
</tr>
<tr>
<td>e1(E)</td>
<td>13 100, 14 81.7, 15 100</td>
</tr>
<tr>
<td>e2(F)</td>
<td>16 16.15, 17 100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-sub DAS Sumber Brantas</th>
<th>tk erosi lahan sawah kemiringan I ~ ton per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>ea2(A)</td>
<td>0.5, 2 0.5, 3 0.5, 4 6.2</td>
</tr>
<tr>
<td>eb2(B)</td>
<td>5 0.6, 6 0.8, 7 5.04, 8 100</td>
</tr>
<tr>
<td>ec2(C)</td>
<td>9 10.35, 10 28.8, 11 19.7</td>
</tr>
<tr>
<td>ed2(D)</td>
<td>12 34.0</td>
</tr>
<tr>
<td>e2(E)</td>
<td>13 50.4, 14 37.1, 15 29.35</td>
</tr>
<tr>
<td>e2(F)</td>
<td>16 100, 17 13.3</td>
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<table>
<thead>
<tr>
<th>Sub-sub DAS Amprong</th>
<th>tk erosi lahan sawah kemiringan I ~ ton per ha</th>
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<tbody>
<tr>
<td>ea3(A)</td>
<td>0.5, 2 0.6, 3 100, 4 5.6</td>
</tr>
<tr>
<td>eb3(B)</td>
<td>5 500, 6 100, 7 100, 8 500</td>
</tr>
<tr>
<td>ec3(C)</td>
<td>9 15.15, 10 5.2, 11 100, 12 8.27</td>
</tr>
<tr>
<td>ed3(D)</td>
<td>13 100, 14 100, 15 100</td>
</tr>
<tr>
<td>e3(E)</td>
<td>16 100, 17 100</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-sub DAS Lesti</th>
<th>tk erosi lahan sawah kemiringan I ~ ton per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>ea4(A)</td>
<td>0.5, 2 0.5, 3 0.6, 4 4.3</td>
</tr>
</tbody>
</table>

Lampiran 12. Lanjutan

<table>
<thead>
<tr>
<th>tk erosi lahan sawah kemiringan I ~ ton per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>eB4(B)</td>
</tr>
<tr>
<td>eC4(C)</td>
</tr>
<tr>
<td>eD4(D)</td>
</tr>
<tr>
<td>eT</td>
</tr>
</tbody>
</table>
eE4(E) tk erosi lahan kebun kemiringan I ~ ton per ha
/18 3.8, 19 100, 20 100, 21 1.8/
eF4(F) tk erosi lahan kebun kemiringan II ~ ton per ha
/22 28.08, 23 100, 24 100, 25 14.04/

* Sub-sub DAS Metro
eA5(A) tk erosi lahan sawah kemiringan I ~ ton per ha
/1 0.5, 2 0.5, 3 0.6, 4 6.3/
eB5(B) tk erosi lahan sawah kemiringan II ~ ton per ha
/5 0.2, 6 100, 7 17.16, 8 7.4/
eC5(C) tk erosi lahan tegal kemiringan I ~ ton per ha
/9 48.8, 10 25.65, 11 500, 12 26.2/
eD5(D) tk erosi lahan tegal kemiringan II ~ ton per ha
/13 29.0, 14 500, 15 500, 16 36.3, 17 500/
eE5(E) tk erosi lahan kebun kemiringan I ~ ton per ha
/18 13.8, 19 100, 20 7.07, 21 100/
eF5(F) tk erosi lahan kebun kemiringan II ~ ton per ha
/22 17.16, 23 100, 24 9.16, 25 100/

* BIAYA PRODUKSI

* Sub-sub DAS Bango
BA1(A) biaya produksi lahan sawah kemiringan I ~ juta Rp per ha
/1 9.996333, 2 6.393629, 3 11.416720, 4 9.679722/
BB1(B) biaya produksi lahan sawah kemiringan II ~ ton per ha
/5 500, 6 500, 7 500, 8 500/
BC1(C) biaya produksi lahan tegal kemiringan I ~ ton per ha
/9 17.028963, 10 5.484968, 11 43.8004, 12 7.051823/
BD1(D) biaya produksi lahan tegal kemiringan II ~ ton per ha
/13 700, 14 5.187143, 15 500, 16 6.511901, 17 500/
BE1(E) biaya produksi lahan kebun kemiringan I ~ ton per ha
/18 7.051823, 19 100, 20 7.07, 21 100/
BF1(F) biaya produksi lahan kebun kemiringan II ~ ton per ha
/22 6.511901, 23 20.623081, 24 500, 25 500/

* Sub-sub DAS Sumber Brantas
BA2(A) biaya produksi lahan sawah kemiringan I ~ juta Rp per ha
/1 9.996333, 2 6.393629, 3 11.416720, 4 9.679722/
BB2(B) biaya produksi lahan sawah kemiringan II ~ ton per ha
/5 8.144792, 6 13.763189, 7 6.380982, 8 500/
BC2(C) biaya produksi lahan tegal kemiringan I ~ ton per ha
/9 17.028963, 10 5.484968, 11 43.8004, 12 7.051823/
BD2(D) biaya produksi lahan tegal kemiringan II ~ ton per ha
/13 17.326500, 14 5.187143, 15 33.751907, 16 500, 17 20.623081/

Lampiran 12. Lanjutan
BE2(E) biaya produksi lahan kebun kemiringan I ~ ton per ha
/18 7.051823, 19 36.465433, 20 500, 21 500/
BF2(F) biaya produksi lahan kebun kemiringan II ~ ton per ha
/22 500, 23 20.623081, 24 13.38655, 25 500/

* Sub-sub DAS Amprong
BA3(A) biaya produksi lahan sawah kemiringan I ~ juta Rp per ha
/1 9.996333, 2 6.393629, 3 500, 4 9.679722/
BB3(B) biaya produksi lahan sawah kemiringan II ~ ton per ha
/5  500,  6  500,  7  500,  8  500/
BC3(C) biaya produksi lahan tegal kemiringan I ~ ton per ha
/9  17.028963, 10  5.484968, 11  500,  12  7.051823/
BD3(D) biaya produksi lahan tegal kemiringan II ~ ton per ha
/13  500,  14  500,  15  500,  16  500,  17  500/
BE3(E) biaya produksi lahan kebun kemiringan I ~ ton per ha
/18  7.051823, 19  500,  20  500,  21  1.390263/
BF3(F) biaya produksi lahan kebun kemiringan II ~ ton per ha
/22  6.511901, 23  20.623081, 24  500,  25  1.120898/

* Sub-sub DAS Lesti
BA4(A) biaya produksi lahan sawah kemiringan I ~ juta Rp per ha
/1  9.996333,  2  6.393629,  3  11.416720,  4  9.679722/
BB4(B) biaya produksi lahan sawah kemiringan II ~ ton per ha
/5  500,  6  500,  7  500,  8  500/
BC4(C) biaya produksi lahan tegal kemiringan I ~ ton per ha
/9  17.028963, 10  5.484968, 11  500,  12  7.051823/
BD4(D) biaya produksi lahan tegal kemiringan II ~ ton per ha
/13  17.326500, 14  5.187143, 15  500,  16  6.511901,  17  500/
BE4(E) biaya produksi lahan kebun kemiringan I ~ ton per ha
/18  7.051823, 19  500,  20  500,  21  1.390263/
BF4(F) biaya produksi lahan kebun kemiringan II ~ ton per ha
/22  6.511901, 23  20 500,  24  500,  25  1.120898/

* Sub-sub DAS Metro
BA5(A) biaya produksi lahan sawah kemiringan I ~ juta Rp per ha
/1  9.996333,  2  6.393629,  3  11.416720,  4  9.679722/
BB5(B) biaya produksi lahan sawah kemiringan II ~ ton per ha
/5  8.144792,  6  500,  7  6.380982,  8  20.646284/
BC5(C) biaya produksi lahan tegal kemiringan I ~ ton per ha
/9  17.028963, 10  5.484968, 11  500,  12  7.051823/
BD5(D) biaya produksi lahan tegal kemiringan II ~ ton per ha
/13  17.326500, 14  500,  15  500,  16  6.511901,  17  500/
BE5(E) biaya produksi lahan kebun kemiringan I ~ ton per ha
/18  7.051823, 19  500,  20  19.26378,  21  500/
BF5(F) biaya produksi lahan kebun kemiringan II ~ ton per ha
/22  6.511901, 23  500,  24  13.386556,  25  500/

Lampiran 12. Lanjutan

* Lahan budidaya yang tersedia
* Sub-sub DAS Bango
TL1B(T) total lahan sawah kemiringan I ~ ha
/2003*2020 3689/
TL2B(T) total lahan sawah kemiringan II ~ ha
/2003*2020 1/
TL3B(T) total lahan tegal kemiringan I ~ ha
/2003*2020 7174/
TL4B(T) total lahan tegal kemiringan II ~ ha
Dalam rangka peningkatan kualitas kebun kemiringan, perlu dilakukan peningkatan kebun kemiringan yang dilakukan oleh PBI. Diharapkan peningkatan kebun kemiringan ini dapat meningkatkan produktivitas kebun kemiringan.

Lampiran 12. Lanjutan

TL6L(T) total lahan kebun kemiringan II ~ ha
/2003*2020 7250/

* Sub-sub DAS Metro

TL1M(T) total lahan sawah kemiringan I ~ ha
/2003*2020 5368/
TL2M(T) total lahan sawah kemiringan II ~ ha
/2003*2020 94/
TL3M(T) total lahan tegal kemiringan I ~ ha
/2003*2020 3442/
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL4M(T)</td>
<td>total lahan tegal kemiringan II ~ ha</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>434/</td>
</tr>
<tr>
<td>TL5M(T)</td>
<td>total lahan kebun kemiringan I ~ ha</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>210/</td>
</tr>
<tr>
<td>TL6M(T)</td>
<td>total lahan kebun kemiringan II ~ ha</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>411/</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB(T)</td>
<td>lahan non-budidaya intensif wil Bango ~ hektar</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>671/</td>
</tr>
<tr>
<td>LS(T)</td>
<td>lahan non-budidaya intensif wil Sb Brantas ~ hektar</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>1811/</td>
</tr>
<tr>
<td>LA(T)</td>
<td>lahan non-budidaya intensif wil Amprong ~ hektar</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>1499/</td>
</tr>
<tr>
<td>LL(T)</td>
<td>lahan non-budidaya intensif wil Lesti ~ hektar</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>2367/</td>
</tr>
<tr>
<td>LM(T)</td>
<td>lahan non-budidaya intensif wil Metro ~ hektar</td>
</tr>
<tr>
<td>/2003*2020</td>
<td>10606/</td>
</tr>
</tbody>
</table>

**Luas lahan non-budidaya intensif**

- **LB(T)**: total luas lahan non-budidaya intensif wil Bango ~ hektar
- **LS(T)**: total luas lahan non-budidaya intensif wil Sb Brantas ~ hektar
- **LA(T)**: total luas lahan non-budidaya intensif wil Amprong ~ hektar
- **LL(T)**: total luas lahan non-budidaya intensif wil Lesti ~ hektar
- **LM(T)**: total luas lahan non-budidaya intensif wil Metro ~ hektar

**Total massa sedimen dan konversi volume sedimen**

- **M11n(T)**: massa sedimen lahan non-budidaya intensif wil Bango ~ ton
- **M12n(T)**: massa sedimen lahan non-budidaya intensif wil SB Brantas ~ ton
- **M13n(T)**: massa sedimen lahan non-budidaya intensif wil Amprong ~ ton
- **M14n(T)**: massa sedimen lahan non-budidaya intensif wil Lesti ~ ton
- **M2n(T)**: massa sedimen lahan non-budidaya intensif wil Metro ~ ton

**Massa sedimen dan diskonto**

- **M1n(T)**: massa sedimen lahan non-budidaya intensif wil hulu Sengguruh ~ ton
- **KVS**: konversi volume sedimen dari massa ~ juta m3
- **ROI(T)**: tingkat diskonto pada tahun t

\[
M1n(T) = M11n(T) + M12n(T) + M13n(T) + M14n(T); \\
KVS = (1/(10**6))*KP*(1/KK); \\
ROI(T) = 1/((1+BGA)**ORD(T));
\]

**VARIABLES**

- **X1B(A,T)**: luas areal aktivitas pd lahan sawah kemiringan I ~ ha
- **X2B(B,T)**: luas areal aktivitas pd lahan sawah kemiringan II ~ ha
- **X3B(C,T)**: luas areal aktivitas pd lahan tegal kemiringan I ~ ha
- **X4B(D,T)**: luas areal aktivitas pd lahan tegal kemiringan II ~ ha
- **X5B(E,T)**: luas areal aktivitas pd lahan kebun kemiringan I ~ ha
- **X6B(F,T)**: luas areal aktivitas pd lahan kebun kemiringan II ~ ha
- **X1S(A,T)**: luas areal aktivitas pd lahan sawah kemiringan I ~ ha
<table>
<thead>
<tr>
<th>X2S(B,T)</th>
<th>luas areal aktivitas pd lahan sawah kemiringan II ~ ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>X3S(C,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan I ~ ha</td>
</tr>
<tr>
<td>X4S(D,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan II ~ ha</td>
</tr>
<tr>
<td>X5S(E,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan I ~ ha</td>
</tr>
<tr>
<td>X6S(F,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan II ~ ha</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>X1A(A,T)</th>
<th>luas areal aktivitas pd lahan sawah kemiringan I ~ ha</th>
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<tbody>
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<tr>
<td>X3A(C,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan I ~ ha</td>
</tr>
<tr>
<td>X4A(D,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan II ~ ha</td>
</tr>
<tr>
<td>X5A(E,T)</td>
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</tr>
<tr>
<td>X6A(F,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan II ~ ha</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>X1L(A,T)</th>
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</thead>
<tbody>
<tr>
<td>X2L(B,T)</td>
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</tr>
<tr>
<td>X3L(C,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan I ~ ha</td>
</tr>
<tr>
<td>X4L(D,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan II ~ ha</td>
</tr>
<tr>
<td>X5L(E,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan I ~ ha</td>
</tr>
<tr>
<td>X6L(F,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan II ~ ha</td>
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</tbody>
</table>

<table>
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<tr>
<th>X1M(A,T)</th>
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<td>X2M(B,T)</td>
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<td>X3M(C,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan I ~ ha</td>
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<td>X4M(D,T)</td>
<td>luas areal aktivitas pd lahan tegal kemiringan II ~ ha</td>
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<tr>
<td>X5M(E,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan I ~ ha</td>
</tr>
<tr>
<td>X6M(F,T)</td>
<td>luas areal aktivitas pd lahan kebun kemiringan II ~ ha</td>
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<table>
<thead>
<tr>
<th>S1B(A,T)</th>
<th>ketebalan lapisan tanah sawah kemiringan I ~ cm</th>
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<tbody>
<tr>
<td>S2B(B,T)</td>
<td>ketebalan lapisan tanah sawah kemiringan II ~ cm</td>
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<tr>
<td>S3B(C,T)</td>
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<thead>
<tr>
<th>S1A(A,T)</th>
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<tr>
<td>S2A(B,T)</td>
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Lampiran 12. Lanjutan

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<tr>
<th>S3A(C,T)</th>
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<tr>
<td>S4A(D,T)</td>
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<td>S5A(E,T)</td>
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<th>S1L(A,T)</th>
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<tr>
<td>S2L(B,T)</td>
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<td>S3L(C,T)</td>
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</tr>
<tr>
<td>S6L(F,T)</td>
<td>ketebalan lapisan tanah kebun kemiringan II ~ cm</td>
</tr>
</tbody>
</table>

| S1M(A,T) | ketebalan lapisan tanah sawah kemiringan I ~ cm |
S2M(B,T) ketebalan lapisan tanah sawah kemiringan II ~ cm
S3M(C,T) ketebalan lapisan tanah tegal kemiringan I ~ cm
S4M(D,T) ketebalan lapisan tanah tegal kemiringan II ~ cm
S5M(E,T) ketebalan lapisan tanah kebun kemiringan I ~ cm
S6M(F,T) ketebalan lapisan tanah kebun kemiringan II ~ cm

Vas(T) volume sedimen yg berasal dari Hulu Sengguruh pd th t ~ juta m³
Vms1(T) volume sedimen masuk Waduk Sengguruh pd th t ~ juta m³
Vms12(T) volume sedimen masuk dr Sengguruh ke Sutami pd th t ~ juta m³
VmsM(T) volume sedimen masuk dr Metro pd th t ~ juta m³
Vsa1(T) volume sedimen tersimpan dlm waduk Sengguruh pd th t ~ juta m³
Vsa2(T) volume sedimen tersimpan dlm waduk Sutami pd th t ~ juta m³
Vsa2a(T) volume air tersimpan dlm ST elv 246-272 m pd th t ~ juta m³
Vsa2b(T) volume air tersimpan dlm ST elv Vss2-246 m pd th t ~ juta m³
Vks1(T) volume sedimen yg dikeruk Sengguruh pd th t ~ juta m³
Wo1(T) debit operasi PLTA Sengguruh pd th t ~ m³ per detik
Wo2(T) debit operasi PLTA Sutami pd th t ~ m³ per detik

MB(T) manfaat bersih DAS ~ juta Rp
OBJ fungsi tujuan ~ juta Rp;

POSITIVE VARIABLES
X1A(A,T), X2A(B,T), X3A(C,T), X4A(D,T), X5A(E,T), X6A(F,T),
X1S(A,T), X2S(B,T), X3S(C,T), X4S(D,T), X5S(E,T), X6S(F,T),
X1B(A,T), X2B(B,T), X3B(C,T), X4B(D,T), X5B(E,T), X6B(F,T),
X1L(A,T), X2L(B,T), X3L(C,T), X4L(D,T), X5L(E,T), X6L(F,T),
X1M(A,T), X2M(B,T), X3M(C,T), X4M(D,T), X5M(E,T), X6M(F,T),
S1A(A,T), S2A(B,T), S3A(C,T), S4A(D,T), S5A(E,T), S6A(F,T),
S1S(A,T), S2S(B,T), S3S(C,T), S4S(D,T), S5S(E,T), S6S(F,T),
S1B(A,T), S2B(B,T), S3B(C,T), S4B(D,T), S5B(E,T), S6B(F,T),
S1L(A,T), S2L(B,T), S3L(C,T), S4L(D,T), S5L(E,T), S6L(F,T),
S1M(A,T), S2M(B,T), S3M(C,T), S4M(D,T), S5M(E,T), S6M(F,T),

Lampiran 12. Lanjutan
Vas(T), Vms1(T), Vms12(T), VmsM(T), Vsa1(T), Vsa2(T), Vsa2a(T), Vsa2b(T),
Vks1(T), Wo1(T), Wo2(T);

EQUATIONS
KS1B(A,T) kendala ketebalan lapisan tanah sawah kemiringan I ~ cm
KS2B(B,T) kendala ketebalan lapisan tanah sawah kemiringan II ~ cm
KS3B(C,T) kendala ketebalan lapisan tanah tegal kemiringan I ~ cm
KS4B(D,T) kendala ketebalan lapisan tanah tegal kemiringan II ~ cm
KS5B(E,T) kendala ketebalan lapisan tanah kebun kemiringan I ~ cm
KS6B(F,T) kendala ketebalan lapisan tanah kebun kemiringan II ~ cm
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<tr>
<td>KTL2B(T)</td>
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1. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

2. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

3. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

4. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

5. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

6. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

7. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

8. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

9. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

10. Diharapkan untuk dibagi ke seluruh anggota dan masyarakat yang terlibat dalam pembangunan dan pengembangan wilayah.

*estimasi manfaat sosial bersih tahunan (Juta Rp)

\[ MMB(T) = E = \]

\[ 3*HPd(a_{01}+b_{101}(1-R_{01}^{S1B(1,T)})-BA1(1))X1B(1,T)+ \]

\[ 2*(HPd(a_{02}+b_{102}(1-R_{02}^{S2B(2,T)})+HJg(a_{06}+b_{106}(1-R_{06}^{S2B(5,T)}))-BB1(5))X2B(5,T)+ \]

\[ 2*(HPd(a_{03}+b_{103}(1-R_{03}^{S3B(9,T)}))-HJr(a_{24}+b_{124}(1-R_{24}^{S2B(8,T)}))-BB1(8))X2B(8,T)+ \]

\[ ((HPd(a_{03}+b_{103}(1-R_{03}^{S3B(10,T)}))+HJg(a_{07}+b_{107}(1-R_{07}^{S3B(10,T)}))+HKc(a_{09}+b_{109}(1-R_{09}^{S3B(10,T)}))-BC1(10))X3B(10,T)+ \]

\[ KTL2M(T) \quad \text{kendala total lahan sawah kemiringan } \ll 1 \text{ ha} \]

\[ KTL3M(T) \quad \text{kendala total lahan tegal kemiringan } \ll 1 \text{ ha} \]

\[ KTL4M(T) \quad \text{kendala total lahan tegal kemiringan } \ll 1 \text{ ha} \]

\[ KTL5M(T) \quad \text{kendala total lahan kebun kemiringan } \ll 1 \text{ ha} \]

\[ KTL6M(T) \quad \text{kendala total lahan kebun kemiringan } \ll 1 \text{ ha} \]

\[ PVas(T) \quad \text{pers sed yg berasal dari Hulu Sengguruh pd th } t \text{ juta m}^3 \]

\[ PVkp1(T) \quad \text{pers kapasitas Waduk Sengguruh pd th } t \text{ juta m}^3 \]

\[ KVkp2(T) \quad \text{kesembangan kapasitas Waduk Sutami pd th } t \text{ juta m}^3 \]

\[ PVms1(T) \quad \text{pers sedimen masuk Waduk Sengguruh pd th } t \text{ juta m}^3 \]

\[ PVms12(T) \quad \text{pers sedimen masuk dr Sengguruh ke Sutami pd th } t \text{ juta m}^3 \]

\[ PVmsM(T) \quad \text{pers sedimen masuk dr Metro pd th } t \text{ juta m}^3 \]

\[ KVss1(T) \quad \text{kesembangan sed tersimpan dlm waduk Sengguruh pd th } t \text{ juta m}^3 \]

\[ KVss2(T) \quad \text{kesembangan sed tersimpan dlm waduk Sutami pd th } t \text{ juta m}^3 \]

\[ PVma1(T) \quad \text{pers air masuk ke waduk Sengguruh pd th } t \text{ juta m}^3 \]

\[ PVmaM(T) \quad \text{pers air masuk dr Metro pd th } t \text{ juta m}^3 \]

\[ Kvs1a(T) \quad \text{kes air tersimpan dlm waduk Sengguruh pd th } t \text{ juta m}^3 \]

\[ Kvs2a(T) \quad \text{kesembangan air tersimpan dlm waduk Sutami pd th } t \text{ juta m}^3 \]

\[ PVsa2b(T) \quad \text{pers air tersimpan dlm ST elv Vss2-246 m pd th } t \text{ juta m}^3 \]
((HKn*(a15+b115*(1-R15**S3B("11",T))))+ 
HWr*(a17+b117*(1-R17**S3B("11",T))))-BC1("11")*X3B("11",T)+ 
(HTb*(a21+b121*(1-R21**S3B("12",T)))-BC1("12")*X3B("12",T)+ 
(2*(HJg*(a08+b108*(1-R08**S4B("13",T)))+ 
HKu*(a13+b113*(1-R13**S4B("13",T))))-BD1("13")*X4B("13",T)+ 
((HPd*(a04+b104*(1-R04**S4B("14",T))))+ 
HJg*(a08+b108*(1-R08**S4B("14",T)))+ 
HKc*(a10+b110*(1-R10**S4B("14",T))))-BD1("14")*X4B("14",T)+ 
((HKn*(a16+b116*(1-R16**S4B("15",T))))+ 
HWr*(a18+b118*(1-R18**S4B("15",T))))-BD1("15")*X4B("15",T)+ 
(HTb*(a22+b122*(1-R22**S4B("16",T)))-BD1("16")*X4B("16",T)+ 
(HAp*(a23+b123*(1-R23**S4B("17",T))))-BD1("17")*X4B("17",T)+ 
SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5B(E,T))))-BE1(E))*X5B(E,T))+ 
SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6B(F,T))))-BF1(F))*X6B(F,T))+ 
* Manfaat Bersih Lahan Sub-sub DAS Sumber Brantas (Juta Rp) 
(3*HPd*(a01+b101*(1-R01**S1S("1",T)))-BA2("1"))*X1S("1",T)+ 
(2*(HPd*(a01+b101*(1-R01**S1S("2",T))))+ 
HJg*(a05+b105*(1-R05**S1S("2",T)))-BA2("2")*X1S("2",T)+ 
(2*(HPd*(a01+b101*(1-R01**S1S("3",T))))+ 
HKu*(a11+b111*(1-R11**S1S("3",T)))-BA2("3")*X1S("3",T)+ 
(HTb*(a19+b119*(1-R19**S1S("4",T)))-BA2("4")*X1S("4",T)+ 
(2*(HPd*(a02+b102*(1-R02**S2S("5",T))))+ 
HJg*(a06+b106*(1-R06**S2S("5",T)))-BB2("5")*X2S("5",T)+ 
Lampiran 12. Lanjutan 
(2*(HPd*(a02+b102*(1-R02**S2S("6",T))))+ 
HKu*(a12+b112*(1-R12**S2S("6",T)))-BB2("6")*X2S("6",T)+ 
(HTb*(a20+b120*(1-R20**S2S("7",T)))-BB2("7")*X2S("7",T)+ 
(HJr*(a24+b124*(1-R24**S2S("8",T)))-BB2("8")*X2S("8",T)+ 
(2*(HJg*(a07+b107*(1-R07**S3S("9",T))))+ 
HKu*(a13+b113*(1-R13**S3S("9",T)))-BC2("9")*X3S("9",T)+ 
((HPd*(a03+b103*(1-R03**S3S("10",T))))+ 
HJg*(a07+b107*(1-R07**S3S("10",T)))+ 
HKc*(a09+b109*(1-R09**S3S("10",T)))-BC2("10")*X3S("10",T)+ 
((HKn*(a15+b115*(1-R15**S3S("11",T))))+ 
HWr*(a17+b117*(1-R17**S3S("11",T)))-BC2("11")*X3S("11",T)+ 
(HTb*(a21+b121*(1-R21**S3S("12",T)))-BC2("12")*X3S("12",T)+
Manfaat Bersih Lahan Sub-sub DAS Amprong (Juta Rp)

1. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

2. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

3. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

4. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

5. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

6. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

7. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

8. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

9. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

10. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

11. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

12. Dihargai mengingat sebagian besar lahan yang dimanfaatkan, terutama dalam bentuk lahan sawah, serta lahan untuk usaha perkebunan dan pertanian, yang ada di dalam DAS Amprong ini.

Lampiran 12. Lanjutan

(HJg*(a08+b108*(1-R08**S4S("13",T)))+
HKu*(a13+b113*(1-R13**S4S("13",T)))-BD2("13"))*X4S("13",T)+

(((HPd*(a04+b104*(1-R04**S4S("14",T)))+HJg*(a08+b108*(1-R08**S4S("14",T)))+
HC*(a10+b110*(1-R10**S4S("14",T)))-BD2("14"))*X4S("14",T)+

(((HKn*(a16+b116*(1-R16**S4S("15",T)))+
HW*(a18+b118*(1-R18**S4S("15",T)))-BD2("15"))*X4S("15",T)+

((HTb*(a22+b122*(1-R22**S4S("16",T)))-BD2("16"))*X4S("16",T)+

((HAp*(a23+b123*(1-R23**S4S("17",T)))-BD2("17"))*X4S("17",T)+

SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5S(E,T)))-BE2(E))*X5S(E,T))+

SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6s(F,T)))-BF2(F))*X6S(F,T))+

* Manfaat Bersih Lahan Sub-sub DAS Amprong (Juta Rp)

(3*HPd*(a01+b101*(1-R01**S1A("1",T)))-BA3("1"))*X1A("1",T)+

(2*(HPd*(a01+b101*(1-R01**S1A("2",T))))+
HJg*(a05+b105*(1-R05**S1A("2",T)))-BA3("2"))*X1A("2",T)+

(2*(HPd*(a01+b101*(1-R01**S1A("3",T)))+
HKu*(a11+b111*(1-R11**S1A("3",T)))-BA3("3"))*X1A("3",T)+

((HTb*(a19+b119*(1-R19**S1A("4",T)))-BA3("4"))*X1A("4",T)+

(2*(HPd*(a02+b102*(1-R02**S2A("5",T))))+
HJg*(a06+b106*(1-R06**S2A("5",T)))-BB3("5"))*X2A("5",T)+

(2*(HPd*(a02+b102*(1-R02**S2A("6",T))))+
HKu*(a12+b112*(1-R12**S2A("6",T)))-BB3("6"))*X2A("6",T)+

((HTb*(a20+b120*(1-R20**S2A("7",T)))-BB3("7"))*X2A("7",T)+

(HJr*(a24+b124*(1-R24**S2A("8",T)))-BB3("8"))*X2A("8",T)+

(2*(HJg*(a07+b107*(1-R07**S3A("9",T))))+
HKu*(a13+b113*(1-R13**S3A("9",T)))-BC3("9"))*X3A("9",T)+

(((HPd*(a03+b103*(1-R03**S3A("10",T))))+
HJg*(a07+b107*(1-R07**S3A("10",T)))+
HKu*(a09+b109*(1-R09**S3A("10",T)))-BC3("10"))*X3A("10",T)+

(((HKn*(a15+b115*(1-R15**S3A("11",T)))+
HW*(a17+b117*(1-R17**S3A("11",T)))-BC3("11"))*X3A("11",T)+

((HTb*(a21+b121*(1-R21**S3A("12",T)))-BC3("12"))*X3A("12",T)+

(2*(HJg*(a08+b108*(1-R08**S4A("13",T))))+
HKu*(a13+b113*(1-R13**S4A("13",T)))-BD3("13"))*X4A("13",T)+

(((HPd*(a04+b104*(1-R04**S4A("14",T)))+HJg*(a08+b108*(1-R08**S4A("14",T)))+
HKu*(a09+b109*(1-R09**S4A("14",T)))-BD3("14"))*X4A("14",T)+

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Manfaat Bersih Lahan Sub-sub DAS Lesti (Juta Rp)

Lampiran 12. Lanjutan
SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5L(E,T)))-
BE4(E))*X5L(E,T))+
SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6L(F,T))-
BF4(F))*X6L(F,T))+

* Manfaat Bersih Lahan Sub-sub DAS Metro (Juta Rp)
(3*HPd*(a01+b101*(1-R01**S1M("1",T)))-BA5("1"))*X1M("1",T)+

(2*(HPd*(a01+b101*(1-R01**S1M("2",T))))+
HJg*(a05+b105*(1-R05**S1M("2",T))))-BA5("2")*X1M("2",T)+

(2*(HPd*(a01+b101*(1-R01**S1M("3",T)))+
HKu*(a11+b111*(1-R11**S1M("3",T))))-BA5("3")*X1M("3",T)+

(HTb*(a19+b119*(1-R19**S1M("4",T)))-BA5("4")*X1M("4",T)+

(2*(HPd*(a02+b102*(1-R02**S2M("5",T))))+
HJg*(a06+b106*(1-R06**S2M("5",T))))-BB5("5")*X2M("5",T)+

(2*(HPd*(a02+b102*(1-R02**S2M("6",T)))+
HKu*(a12+b112*(1-R12**S2M("6",T))))-BB5("6")*X2M("6",T)+

(HTb*(a20+b120*(1-R20**S2M("7",T)))-BB5("7")*X2M("7",T)+

(HJr*(a24+b124*(1-R24**S2M("8",T)))-BB5("8")*X2M("8",T)+

(2*(HJg*(a07+b107*(1-R07**S3M("9",T))))+
HKu*(a13+b113*(1-R13**S3M("9",T))))-BC5("9")*X3M("9",T)+

(((HPd*(a03+b103*(1-R03**S3M("10",T)))+HJg*(a07+b107*(1-R07**S3M("10",T)))+
HKc*(a09+b109*(1-R09**S3M("10",T))))-BC5("10")*X3M("10",T)+

Lampiran 12. Lanjutan
(((HKn*(a15+b115*(1-R15**S3M("11",T)))+
HWr*(a17+b117*(1-R17**S3M("11",T))))-BC5("11")*X3M("11",T)+

(HTb*(a21+b121*(1-R21**S3M("12",T)))-BC5("12")*X3M("12",T)+

(2*(HJg*(a08+b108*(1-R08**S4M("13",T)))+
HKu*(a13+b113*(1-R13**S4M("13",T))))-BD5("13")*X4M("13",T)+

(((HPd*(a04+b104*(1-R04**S4M("14",T)))+HJg*(a08+b108*(1-R08**S4M("14",T)))+
HKc*(a10+b110*(1-R10**S4M("14",T))))-BD5("14")*X4M("14",T)+

(((HKn*(a16+b116*(1-R16**S4M("15",T)))+
HWr*(a18+b118*(1-R18**S4M("15",T))))-BD5("15")*X4M("15",T)+

(HTb*(a22+b122*(1-R22**S4M("16",T)))-BD5("16")*X4M("16",T)+

(HAp*(a23+b123*(1-R23**S4M("17",T)))-BD5("17")*X4M("17",T)+

SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5M(E,T)))-
BE5(E))*X5M(E,T))+
SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6M(F,T)))-
BF5(F))*X6M(F,T)+

SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5L(E,T)))-
BE4(E))*X5L(E,T))+
SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6L(F,T)))-
BF4(F))*X6L(F,T))+

SUM(E, (HK(E)*(a25(E)+b125(E)*(1-R25(E)**S5L(E,T)))-
BE4(E))*X5L(E,T))+
SUM(F, (HC(F)*(a26(F)+b126(F)*(1-R26(F)**S6L(F,T)))-
BF4(F))*X6L(F,T))+
* Manfaat Air Waduk Untuk Listrik (Juta Rp)
  \[2 \times PE1 \times (1.22 \times Wo1(T)) +
  3 \times PE2 \times (2.46 \times Wo2(T)) +
  0.65 \times PM \times Wo2(T) -
  \]

* Manfaat Air Waduk Untuk Pengairan dan Industri (Juta Rp)
  \[9.07 \times PI \times Wo2(T) +
  0.65 \times PM \times Wo2(T) -
  \]

* Biaya Sosial Pengerukan Sedimen Waduk Sengguruh (Juta Rp)
  \[BYPK \times Vks1(T); \]

* Maksimisasi fungsi tujuan (Juta Rp):
  \[ZZ. \quad OBJ = \sum(T, ROI(T) \times MB(T-1)) +
  ROI("2020") + (PE2 \times 0.0067 \times (Vsa2("2020")/CV2) +
  ((Vsa2("2020")/CV2) \times (0.2875 \times PI + 0.0206 \times PM)); \]

* Kendala transisi ketebalan lapisan tanah pada wilayah (cm):
  - Sub-sub DAS Bango
    - KS1B(A,T+1) \quad S1B(A,T+1) = S1B(A,T) - eA1(A)/FKL;
    - KS2B(B,T+1) \quad S2B(B,T+1) = S2B(B,T) - eB1(B)/FKL;
    - KS3B(C,T+1) \quad S3B(C,T+1) = S3B(C,T) - eC1(C)/FKL;
    - KS4B(D,T+1) \quad S4B(D,T+1) = S4B(D,T) - eD1(D)/FKL;
    - KS5B(E,T+1) \quad S5B(E,T+1) = S5B(E,T) - eE1(E)/FKL;
    - KS6B(F,T+1) \quad S6B(F,T+1) = S6B(F,T) - eF1(F)/FKL;

  - Sub-sub DAS Sumber Brantas
    - KS1S(A,T+1) \quad S1S(A,T+1) = S1S(A,T) - eA2(A)/FKL;
    - KS2S(B,T+1) \quad S2S(B,T+1) = S2S(B,T) - eB2(B)/FKL;

  - Sub-sub DAS Ampron
    - KS1A(A,T+1) \quad S1A(A,T+1) = S1A(A,T) - eA3(A)/FKL;
    - KS2A(B,T+1) \quad S2A(B,T+1) = S2A(B,T) - eB3(B)/FKL;
    - KS3A(C,T+1) \quad S3A(C,T+1) = S3A(C,T) - eC3(C)/FKL;
    - KS4A(D,T+1) \quad S4A(D,T+1) = S4A(D,T) - eD3(D)/FKL;
    - KS5A(E,T+1) \quad S5A(E,T+1) = S5A(E,T) - eE3(E)/FKL;
    - KS6A(F,T+1) \quad S6A(F,T+1) = S6A(F,T) - eF3(F)/FKL;

  - Sub-sub DAS Lesti
    - KS1L(A,T+1) \quad S1L(A,T+1) = S1L(A,T) - eA4(A)/FKL;
    - KS2L(B,T+1) \quad S2L(B,T+1) = S2L(B,T) - eB4(B)/FKL;
    - KS3L(C,T+1) \quad S3L(C,T+1) = S3L(C,T) - eC4(C)/FKL;
    - KS4L(D,T+1) \quad S4L(D,T+1) = S4L(D,T) - eD4(D)/FKL;
    - KS5L(E,T+1) \quad S5L(E,T+1) = S5L(E,T) - eE4(E)/FKL;
    - KS6L(F,T+1) \quad S6L(F,T+1) = S6L(F,T) - eF4(F)/FKL;

  - Sub-sub DAS Metro
    - KS1M(A,T+1) \quad S1M(A,T+1) = S1M(A,T) - eA5(A)/FKL;
KS2M(B,T+1) = S2M(B,T) – eB5(B)/FKL;
KS3M(C,T+1) = S3M(C,T) – eC5(C)/FKL;
KS4M(D,T+1) = S4M(D,T) – eD5(D)/FKL;
KS5M(E,T+1) = S5M(E,T) – eE5(E)/FKL;
KS6M(F,T+1) = S6M(F,T) – eF5(F)/FKL;

* Kendala keseimbangan air waduk tahunan

* Volume sedimen dr wilayah Hulu Sengguruh
PVas(T) = KVS* (SUM(A,X1B(A,T)*SDR1*eA1(A)) + SUM(B,X2B(B,T)*SDR1*eB1(B)) + SUM(C,X3B(C,T)*SDR1*eC1(C)) + SUM(D,X4B(D,T)*SDR1*eD1(D)) + SUM(E,X5B(E,T)*SDR1*eE1(E)) + SUM(F,X6B(F,T)*SDR1*eF1(F)) + SUM(A,X1S(A,T)*SDR2*eA2(A)) + SUM(B,X2S(B,T)*SDR2*eB2(B)) + SUM(C,X3S(C,T)*SDR2*eC2(C)) + SUM(D,X4S(D,T)*SDR2*eD2(D)) + SUM(E,X5S(E,T)*SDR2*eE2(E)) + SUM(F,X6S(F,T)*SDR2*eF2(F)) + SUM(A,X1A(A,T)*SDR3*eA3(A)) + SUM(B,X2A(B,T)*SDR3*eB3(B)) + SUM(C,X3A(C,T)*SDR3*eC3(C)) + SUM(D,X4A(D,T)*SDR3*eD3(D)) + SUM(E,X5A(E,T)*SDR3*eE3(E)) + SUM(F,X6A(F,T)*SDR3*eF3(F)) + SUM(A,X1L(A,T)*SDR4*eA4(A)) + SUM(B,X2L(B,T)*SDR4*eB4(B)) + SUM(C,X3L(C,T)*SDR4*eC4(C)) + SUM(D,X4L(D,T)*SDR4*eD4(D)) + SUM(E,X5L(E,T)*SDR4*eE4(E)) + SUM(F,X6L(F,T)*SDR4*eF4(F)) + M1n(T));

PVmsM(T) = KVS* (SUM(A,X1M(A,T)*SDR5*eA5(A)) + SUM(B,X2M(B,T)*SDR5*eB5(B)) + SUM(C,X3M(C,T)*SDR5*eC5(C)) + SUM(D,X4M(D,T)*SDR5*eD5(D)) + SUM(E,X5M(E,T)*SDR5*eE5(E)) + SUM(F,X6M(F,T)*SDR5*eF5(F)) + M2n(T));

* Volume air masuk (inlow) ke Waduk Sengguruh
PVma1(T) = DS1*(LS(T) + SUM(A,X1B(A,T)) + SUM(B,X2B(B,T)) + SUM(C,X3B(C,T)) + SUM(D,X4B(D,T)) + SUM(E,X5B(E,T)) + SUM(F,X6B(F,T))) + DS2*(LS(T) + SUM(A,X1S(A,T)) + SUM(B,X2S(B,T)) + SUM(C,X3S(C,T)) + SUM(D,X4S(D,T)) + SUM(E,X5S(E,T)) + SUM(F,X6S(F,T))) + DS3*(LS(T) + SUM(A,X1A(A,T)) + SUM(B,X2A(B,T)) + SUM(C,X3A(C,T)) + SUM(D,X4A(D,T)) + SUM(E,X5A(E,T)) + SUM(F,X6A(F,T))) + DS4*(LL(T) + SUM(A,X1L(A,T)) + SUM(B,X2L(B,T)) + SUM(C,X3L(C,T)) + SUM(D,X4L(D,T)) + SUM(E,X5L(E,T)) + SUM(F,X6L(F,T)));

Lampiran 12. Lanjutan

* Volume sedimen dr wilayah Sub-Sub DAS Metro
PVmsM(T) = KVS* (SUM(A,X1M(A,T)*SDR5*eA5(A)) + SUM(B,X2M(B,T)*SDR5*eB5(B)) + SUM(C,X3M(C,T)*SDR5*eC5(C)) + SUM(D,X4M(D,T)*SDR5*eD5(D)) + SUM(E,X5M(E,T)*SDR5*eE5(E)) + SUM(F,X6M(F,T)*SDR5*eF5(F)) + M2n(T));

PVma1(T) = DS1*(LS(T) + SUM(A,X1L(A,T)) + SUM(B,X2L(B,T)) + SUM(C,X3L(C,T)) + SUM(D,X4L(D,T)) + SUM(E,X5L(E,T)) + SUM(F,X6L(F,T)));

* Volume air masuk (inlow) ke Waduk Sengguruh
PVma1(T) = DS1*(LS(T) + SUM(A,X1B(A,T)) + SUM(B,X2B(B,T)) + SUM(C,X3B(C,T)) + SUM(D,X4B(D,T)) + SUM(E,X5B(E,T)) + SUM(F,X6B(F,T))) + DS2*(LS(T) + SUM(A,X1S(A,T)) + SUM(B,X2S(B,T)) + SUM(C,X3S(C,T)) + SUM(D,X4S(D,T)) + SUM(E,X5S(E,T)) + SUM(F,X6S(F,T))) + DS3*(LS(T) + SUM(A,X1A(A,T)) + SUM(B,X2A(B,T)) + SUM(C,X3A(C,T)) + SUM(D,X4A(D,T)) + SUM(E,X5A(E,T)) + SUM(F,X6A(F,T))) + DS4*(LL(T) + SUM(A,X1L(A,T)) + SUM(B,X2L(B,T)) + SUM(C,X3L(C,T)) + SUM(D,X4L(D,T)) + SUM(E,X5L(E,T)) + SUM(F,X6L(F,T)));
1. Volume air dari Sub-Sub DAS Metro
\[ PV_{maM}(T) = E = DS_5^*(LM(T) + SUM(A,X1M(A,T)) + SUM(B,X2M(B,T)) + SUM(C,X3M(C,T)) + SUM(D,X4M(D,T)) + SUM(E,X5M(E,T)) + SUM(F,X6M(F,T))]; \]

2. Keseimbangan waduk Sengguruh
\[ PV_{kp1}(T+1) = E = Vma1(T)-31.53*Wo1(T)+Vsa1(T)+Vms1(T)-Vks1(T)+Vss1(T); \]
\[ PV_{ms1}(T) = E = 0.4*Vas(T); \]
\[ KV_{ss1}(T+1) = E = Vss1(T)+Vms1(T)-Vks1(T); \]
\[ KV_{sa1}(T) = E = Vkp1(T)-Vss1(T); \]

3. Keseimbangan waduk Sutami
\[ KV_{kp2}(T+1) = E = 31.53*Wo1(T)+VmaM(T)-31.53*Wo2(T)+Vsa2(T)+Vms12(T)+0.98*VmsM(T)+Vss2(T); \]
\[ KV_{ss2}(T+1) = E = Vss2(T)+Vms12(T)+VmsM(T); \]
\[ PV_{ms12}(T) = E = 0.56*Vas(T); \]
\[ KV_{sa2}(T) = E = Vsa2a(T)+Vsa2b(T); \]
\[ PV_{sa2b}(T) = E = 90-Vss2(T); \]

Lampiran 12. Lanjutan

* Kendala luas lahan (Ha) pada:

* Sub-sub DAS Bango
\[ KT_{L1B}(T) = L = SUM(A,X1B(A,T)) \]
\[ KT_{L2B}(T) = L = SUM(B,X2B(B,T)) \]
\[ KT_{L3B}(T) = L = SUM(C,X3B(C,T)) \]
\[ KT_{L4B}(T) = L = SUM(D,X4B(D,T)) \]
\[ KT_{L5B}(T) = L = SUM(E,X5B(E,T)) \]
\[ KT_{L6B}(T) = L = SUM(F,X6B(F,T)) \]

* Sub-sub DAS Sumber Brantas
\[ KT_{L1S}(T) = L = SUM(A,X1S(A,T)) \]
\[ KT_{L2S}(T) = L = SUM(B,X2S(B,T)) \]
\[ KT_{L3S}(T) = L = SUM(C,X3S(C,T)) \]
\[ KT_{L4S}(T) = L = SUM(D,X4S(D,T)) \]
\[ KT_{L5S}(T) = L = SUM(E,X5S(E,T)) \]
\[ KT_{L6S}(T) = L = SUM(F,X6S(F,T)) \]

* Sub-sub DAS Amprong
\[ KT_{L1A}(T) = L = SUM(A,X1A(A,T)) \]
\[ KT_{L2A}(T) = L = SUM(B,X2A(B,T)) \]
\[ KT_{L3A}(T) = L = SUM(C,X3A(C,T)) \]
\[ KT_{L4A}(T) = L = SUM(D,X4A(D,T)) \]
\[ KT_{L5A}(T) = L = SUM(E,X5A(E,T)) \]
\[ KT_{L6A}(T) = L = SUM(F,X6A(F,T)) \]

* Sub-sub DAS Lesti
KTL1L(T) .. \sum(A \cdot X1L(A,T)) = L = TL1L(T);
KTL2L(T) .. \sum(B \cdot X2L(B,T)) = L = TL2L(T);
KTL3L(T) .. \sum(C \cdot X3L(C,T)) = L = TL3L(T);
KTL4L(T) .. \sum(D \cdot X4L(D,T)) = L = TL4L(T);
KTL5L(T) .. \sum(E \cdot X5L(E,T)) = L = TL5L(T);
KTL6L(T) .. \sum(F \cdot X6L(F,T)) = L = TL6L(T);

* Sub-sub DAS Metro
KTL1M(T) .. \sum(A \cdot X1M(A,T)) = L = TL1M(T);
KTL2M(T) .. \sum(B \cdot X2M(B,T)) = L = TL2M(T);
KTL3M(T) .. \sum(C \cdot X3M(C,T)) = L = TL3M(T);
KTL4M(T) .. \sum(D \cdot X4M(D,T)) = L = TL4M(T);
KTL5M(T) .. \sum(E \cdot X5M(E,T)) = L = TL5M(T);
KTL6M(T) .. \sum(F \cdot X6M(F,T)) = L = TL6M(T);

* Kendala ketebalan lapisan awal (cm) pada:

* Sub-sub DAS Bango
S1B.FX(A,"2003") = 89.65; S2B.FX(B,"2003") = 89.65;
S3B.FX(C,"2003") = 89.65; S4B.FX(D,"2003") = 89.65;
S5B.FX(E,"2003") = 89.65; S6B.FX(F,"2003") = 89.65;

* Sub-sub DAS Sumber Brantas
S1S.FX(A,"2003") = 87.04; S2S.FX(B,"2003") = 87.04;
S3S.FX(C,"2003") = 87.04; S4S.FX(D,"2003") = 87.04;
S5S.FX(E,"2003") = 87.04; S6S.FX(F,"2003") = 87.04;

* Sub-sub DAS Amprong
S1A.FX(A,"2003") = 89.25; S2A.FX(B,"2003") = 89.25;
S3A.FX(C,"2003") = 89.25; S4A.FX(D,"2003") = 89.25;
S5A.FX(E,"2003") = 89.25; S6A.FX(F,"2003") = 89.25;

* Sub-sub DAS Lesti
S1L.FX(A,"2003") = 86.46; S2L.FX(B,"2003") = 86.46;
S3L.FX(C,"2003") = 86.46; S4L.FX(D,"2003") = 86.46;
S5L.FX(E,"2003") = 86.46; S6L.FX(F,"2003") = 86.46;

* Sub-sub DAS Metro
S1M.FX(A,"2003") = 84.84; S2M.FX(B,"2003") = 84.84;
S3M.FX(C,"2003") = 84.84; S4M.FX(D,"2003") = 84.84;
S5M.FX(E,"2003") = 84.84; S6M.FX(F,"2003") = 84.84;

* Batas terbawah & teratas volume air & sedimen tersimpan (juta m3)
Wo1.LO(T) = 19.90;
Wo1.UP(T) = 91.50;
Wo2.UP(T) = 51.39;
Vss1.FX("2003") = 0.32;

Vsa1.FX("2003") = 2.00;
Vss2.FX("2003") = 60.51;
Vss2.UP(T) = 90.00;
Vsa2a.FX(T) = 146.12;
Vsa2b.FX("2003") = 29.00;

* SOLUTION
MODEL MODELAKHIR /ALL/;
OPTION DECIMALS=4;
MODELAKHIR.ITERLIM=8000;
OPTION NLP = MINOS5;
MODELAKHIR.OPTFILE=1;
SOLVE MODELAKHIR USING NLP MAXIMIZING OBJ;