

Article

# Land Cover Changes in Open-cast Mining Complexes Based on High-resolution Remote Sensing Data

Filipe Silveira Nascimento <sup>1,2</sup>, Markus Gastauer <sup>2</sup>, Pedro Walfir M. Souza-Filho <sup>2,3,\*</sup>, Wilson R. Nascimento Jr. <sup>2</sup>, Diogo C. Santos <sup>2</sup> and Marlene F. Costa <sup>4</sup>

<sup>1</sup> Vale S.A. Mina de Águas Claras (MAC), Nova Lima, Minas Gerais 34006-270, Brazil; filipe.silveira@vale.com

<sup>2</sup> Instituto Tecnológico Vale. Belém, Pará 66055-090, Brazil; markus.gastauer@itv.org, pedro.martins.souza@itv.org, wilson.nascimento@itv.org, diogo.correa@pq.itv.org

<sup>3</sup> Geosciences Institute, Universidade Federal do Pará. Belém, Pará 66075-110, Brazil; pedro.martins.souza@itv.org

<sup>4</sup> Vale S.A. Gerência de Meio Ambiente Corredor Norte, São Luís, Maranhão 65085-582, Brazil; marlene.costa@vale.com

\* Correspondence: pedro.martins.souza@itv.org; Tel.: +55-91-3213-5563 (P.W.M.S.F.)

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## Supplementary

**Table S1.** Confusion matrix for image classification: a) 2011 Ikonos; b) 2012 GeoEye; c) 2013 Ikonos; and d) 2015 WorldView-3. The matrix shows the number of verification points, omission (OE) and commission (CE) errors, user (UA) and producer's (PA) accuracy, Kappa index per class, overall accuracy (OA).

| (A) 2011 Ikonos | Water  | Mine  | Canga | Forest | Revegetation | Raw total | UA (%) | CE (%) |
|-----------------|--------|-------|-------|--------|--------------|-----------|--------|--------|
| Water           | 8      | 0     | 0     | 0      | 0            | 8         | 100.00 | 0.00   |
| Mine            | 0      | 187   | 1     | 2      | 17           | 207       | 90.34  | 9.66   |
| Canga           | 0      | 2     | 81    | 1      | 0            | 84        | 96.43  | 3.57   |
| Forest          | 0      | 5     | 16    | 649    | 4            | 674       | 96.29  | 3.71   |
| Revegetation    | 0      | 11    | 1     | 1      | 38           | 51        | 74.51  | 25.49  |
| Column total    | 8      | 205   | 99    | 653    | 59           | 1024      |        |        |
| PA (%)          | 100.00 | 91.22 | 81.82 | 99.39  | 64.41        | 963       | OA=    | 94.04  |
| OE (%)          | 0.00   | 8.78  | 18.18 | 0.61   | 35.59        |           |        |        |
| Kappa per Class | 1.00   | 0.87  | 0.96  | 0.89   | 0.73         |           |        |        |
| B) 2012 GeoEye  | Water  | Mine  | Canga | Forest | Revegetation | Raw total | UA (%) | CE (%) |
| Water           | 10     | 0     | 0     | 2      | 1            | 13        | 76.92  | 23.08  |
| Mine            | 0      | 200   | 2     | 11     | 13           | 226       | 88.50  | 11.50  |
| Canga           | 2      | 2     | 67    | 7      | 0            | 78        | 85.90  | 14.10  |
| Forest          | 0      | 18    | 19    | 605    | 6            | 648       | 93.36  | 6.64   |
| Revegetation    | 0      | 11    | 0     | 5      | 43           | 59        | 72.88  | 27.12  |
| Column total    | 12     | 231   | 88    | 630    | 63           | 1024      |        |        |
| PA (%)          | 83.33  | 86.58 | 76.14 | 96.03  | 68.25        | 925       | OA=    | 90.33  |
| OE (%)          | 16.67  | 13.42 | 23.86 | 3.97   | 31.75        |           |        |        |
| Kappa per Class | 0.76   | 0.85  | 0.84  | 0.83   | 0.71         |           |        |        |
| (C) 2013 Ikonos | Water  | Mine  | Canga | Forest | Revegetation | Raw total | UA (%) | CE (%) |
| Water           | 3      | 0     | 0     | 0      | 1            | 4         | 75.00  | 25.00  |
| Mine            | 2      | 193   | 1     | 4      | 31           | 231       | 83.55  | 16.45  |
| Canga           | 0      | 2     | 72    | 2      | 0            | 76        | 94.74  | 5.26   |
| Forest          | 0      | 6     | 16    | 627    | 4            | 653       | 96.02  | 3.98   |

|                             |          |            |           |            |              |           |        |              |
|-----------------------------|----------|------------|-----------|------------|--------------|-----------|--------|--------------|
| Revegetation                | 0        | 5          | 1         | 2          | <b>52</b>    | 60        | 86.67  | 13.33        |
| <b>Column total</b>         | 5        | 206        | 90        | 635        | 88           | 1024      |        |              |
| PA (%)                      | 60.00    | 93.69      | 80.00     | 98.74      | 59.09        | 947       | OA=    | <b>92.48</b> |
| OE (%)                      | 40.00    | 6.31       | 20.00     | 1.26       | 40.91        |           |        |              |
| <b>Kappa per Class</b>      | 0.75     | 0.79       | 0.94      | 0.89       | 0.85         |           |        |              |
| <b>(D) 2015 WorldView-3</b> | Water    | Mine       | Canga     | Forest     | Revegetation | Raw total | UA (%) | CE (%)       |
| Water                       | <b>4</b> | 2          | 0         | 0          | 0            | 6         | 66.67  | 33.33        |
| Mine                        | 2        | <b>209</b> | 7         | 10         | 16           | 244       | 85.66  | 14.34        |
| Canga                       | 0        | 5          | <b>52</b> | 3          | 0            | 60        | 86.67  | 13.33        |
| Forest                      | 0        | 5          | 12        | <b>625</b> | 1            | 643       | 97.20  | 2.80         |
| Revegetation                | 0        | 12         | 1         | 5          | <b>53</b>    | 71        | 74.65  | 25.35        |
| <b>Column total</b>         | 6        | 233        | 72        | 643        | 70           | 1024      |        |              |
| PA (%)                      | 96.55    | 94.12      | 90.91     | 95.24      | 89.47        | 943       | OA=    | <b>92.09</b> |
| OE (%)                      | 3.45     | 5.88       | 9.09      | 4.76       | 10.53        |           |        |              |
| <b>Kappa per Class</b>      | 0.66     | 0.81       | 0.85      | 0.92       | 0.72         |           |        |              |

**Table S2.** Normalized confusion matrices: a) 2011 Ikonos; b) 2012 GeoEye; c) 2013 Ikonos; and d) 2015 WorldView-3. The matrix shows the number of verification points, omission (OE) and commission (CE) errors, user (UA) and producer's (PA) accuracy, Kappa index per class, overall accuracy (OA), overall disagreement (OD); allocation disagreement (AD); and quantity disagreement (QD).

| <b>(A) 2011 Ikonos</b>      | <b>Water</b> | <b>Mine</b> | <b>Canga</b> | <b>Forest</b> | <b>Revegetation</b> | <b>Total</b> | <b>UA (%)</b> | <b>CE (%)</b> | <b>Quant. Disc.</b> |
|-----------------------------|--------------|-------------|--------------|---------------|---------------------|--------------|---------------|---------------|---------------------|
| Water                       | 0.0078       | 0.0000      | 0.0000       | 0.0000        | 0.0000              | 0.0078       | 100.00        | 0.00          | 0.00                |
| Mine                        | 0.0000       | 0.1826      | 0.0010       | 0.0020        | 0.0166              | 0.2021       | 90.34         | 9.66          | 0.20                |
| Canga                       | 0.0000       | 0.0020      | 0.0791       | 0.0010        | 0.0000              | 0.0820       | 96.43         | 3.57          | 1.46                |
| Forest                      | 0.0000       | 0.0049      | 0.0156       | 0.6338        | 0.0039              | 0.6582       | 96.29         | 3.71          | 2.05                |
| Revegetation                | 0.0000       | 0.0107      | 0.0010       | 0.0010        | 0.0371              | 0.0498       | 74.51         | 25.49         | 0.78                |
| Total                       | 0.0078       | 0.2002      | 0.0967       | 0.6377        | 0.0576              | AO           | 94.04         | QD            | 2.25                |
| PA (%)                      | 100.00       | 91.22       | 81.82        | 99.39         | 64.41               | OD           | 5.96          |               |                     |
| OE (%)                      | 0.00         | 8.78        | 18.18        | 0.61          | 35.59               |              |               |               |                     |
| <b>Alloc. Disc.</b>         | <b>0.00</b>  | <b>3.52</b> | <b>0.59</b>  | <b>0.78</b>   | <b>2.54</b>         | <b>AD</b>    | <b>3.71</b>   |               |                     |
| <b>(B) 2012 GeoEye</b>      | <b>Water</b> | <b>Mine</b> | <b>Canga</b> | <b>Forest</b> | <b>Revegetation</b> | <b>Total</b> | <b>UA (%)</b> | <b>CE (%)</b> | <b>Quant. Disc.</b> |
| Water                       | 0.0098       | 0.0000      | 0.0000       | 0.0020        | 0.0010              | 0.0127       | 76.92         | 23.08         | 0.10                |
| Mine                        | 0.0000       | 0.1953      | 0.0020       | 0.0107        | 0.0127              | 0.2207       | 88.50         | 11.50         | 0.49                |
| Canga                       | 0.0020       | 0.0020      | 0.0654       | 0.0068        | 0.0000              | 0.0762       | 85.90         | 14.10         | 0.98                |
| Forest                      | 0.0000       | 0.0176      | 0.0186       | 0.5908        | 0.0059              | 0.6328       | 93.36         | 6.64          | 1.76                |
| Revegetation                | 0.0000       | 0.0107      | 0.0000       | 0.0049        | 0.0420              | 0.0576       | 72.88         | 27.12         | 0.39                |
| Total                       | 0.0117       | 0.2256      | 0.0859       | 0.6152        | 0.0615              | AO           | 90.33         | QD            | 1.86                |
| PA (%)                      | 83.33        | 86.58       | 76.14        | 96.03         | 68.25               | OD           | 9.67          |               |                     |
| OE (%)                      | 16.67        | 13.42       | 23.86        | 3.97          | 31.75               |              |               |               |                     |
| <b>Alloc. Disc.</b>         | <b>0.39</b>  | <b>5.08</b> | <b>2.15</b>  | <b>4.88</b>   | <b>3.13</b>         | <b>AD</b>    | <b>7.81</b>   |               |                     |
| <b>(C) 2013 Ikonos</b>      | <b>Water</b> | <b>Mine</b> | <b>Canga</b> | <b>Forest</b> | <b>Revegetation</b> | <b>Total</b> | <b>UA (%)</b> | <b>CE (%)</b> | <b>Quant. Disc.</b> |
| Water                       | 0.0029       | 0.0000      | 0.0000       | 0.0000        | 0.0010              | 0.0039       | 75.00         | 25.00         | 0.10                |
| Mine                        | 0.0020       | 0.1885      | 0.0010       | 0.0039        | 0.0303              | 0.2256       | 83.55         | 16.45         | 2.44                |
| Canga                       | 0.0000       | 0.0020      | 0.0703       | 0.0020        | 0.0000              | 0.0742       | 94.74         | 5.26          | 1.37                |
| Forest                      | 0.0000       | 0.0059      | 0.0156       | 0.6123        | 0.0039              | 0.6377       | 96.02         | 3.98          | 1.76                |
| Revegetation                | 0.0000       | 0.0049      | 0.0010       | 0.0020        | 0.0508              | 0.0586       | 86.67         | 13.33         | 2.73                |
| Total                       | 0.0049       | 0.2012      | 0.0879       | 0.6201        | 0.0859              | AO           | 92.48         | QD            | 4.20                |
| PA (%)                      | 60.00        | 93.69       | 80.00        | 98.74         | 59.09               | OD           | 7.52          |               |                     |
| OE (%)                      | 40.00        | 6.31        | 20.00        | 1.26          | 40.91               |              |               |               |                     |
| <b>Alloc. Disc.</b>         | <b>0.20</b>  | <b>2.54</b> | <b>0.78</b>  | <b>1.56</b>   | <b>1.56</b>         | <b>AD</b>    | <b>3.32</b>   |               |                     |
| <b>(D) 2015 WorldView-3</b> | <b>Water</b> | <b>Mine</b> | <b>Canga</b> | <b>Forest</b> | <b>Revegetation</b> | <b>Total</b> | <b>UA (%)</b> | <b>CE (%)</b> | <b>Quant. Disc.</b> |
| Water                       | 0.0039       | 0.0020      | 0.0000       | 0.0000        | 0.0000              | 0.0059       | 66.67         | 33.33         | 0.00                |
| Mine                        | 0.0020       | 0.2041      | 0.0068       | 0.0098        | 0.0156              | 0.2383       | 85.66         | 14.34         | 1.07                |
| Canga                       | 0.0000       | 0.0049      | 0.0508       | 0.0029        | 0.0000              | 0.0586       | 86.67         | 13.33         | 1.17                |
| Forest                      | 0.0000       | 0.0049      | 0.0117       | 0.6104        | 0.0010              | 0.6279       | 97.20         | 2.80          | 0.00                |
| Revegetation                | 0.0000       | 0.0117      | 0.0010       | 0.0049        | 0.0518              | 0.0693       | 74.65         | 25.35         | 0.10                |
| Total                       | 0.0059       | 0.2275      | 0.0703       | 0.6279        | 0.0684              | AO           | 92.09         | QD            | 1.17                |
| PA (%)                      | 66.67        | 89.70       | 72.22        | 97.20         | 75.71               | OD           | 7.91          |               |                     |
| OE (%)                      | 33.33        | 10.30       | 27.78        | 2.80          | 24.29               |              |               |               |                     |
| <b>Alloc. Disc.</b>         | <b>0.39</b>  | <b>4.69</b> | <b>1.56</b>  | <b>3.52</b>   | <b>3.32</b>         | <b>AD</b>    | <b>6.74</b>   |               |                     |

