

Annual Report for Year 1  
January – December, 2013  
NASA Land Cover Land Use Change Program:

## Social drivers of land cover change around African transboundary Peace Parks

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## Statement of Work

### Project activities:

Year 1 activities focused on data acquisition and preprocessing in preparation for the mapping and analyses planned within this project. First, we have compiled Landsat data for multi-year Landsat-scale land cover change analysis within and outside the Great Limpopo Transfrontier Park (GLTP). Second, we have acquired a suite of very high resolution (VHR) imagery for mapping and characterization of village structure in Mozambique. And finally, we have compiled and started to analyze the existing socio-economic survey data.

### *Multi-year Landsat-scale land cover mapping and change analysis*

We have compiled, downloaded, evaluated, and pre-processed all available Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) imagery between 1984 and 2011. Landsat 5 and 7 data has been converted to surface reflectance using LEDAPS method (Masek et al., 2006). Landsat 4 data have been converted to top of atmosphere reflectance. According to available climatological data (provided by the Norwegian Meteorological Institute and the Norwegian Broadcasting Corporation and made available on <http://www.holidaycheck.com/di/52c9ddf5-978e-3645-a7f1-00127859d625>), the rainy season in the GLTP occurs starting in December and continuing through March, April through July are the peak vegetation (i.e. “wet”) season months, and August – November are the “dry” season months. The three relevant Landsat WRS2 path row tiles have been composited into a seasonal mosaic (dry and wet season) wherever available with an aim to develop two seasonal mosaics for each year to support consistent characterization of land cover and land use in and around GLTP between 1984 and 2012. Table 1 lists the Landsat scenes used in the development of seasonal mosaics.

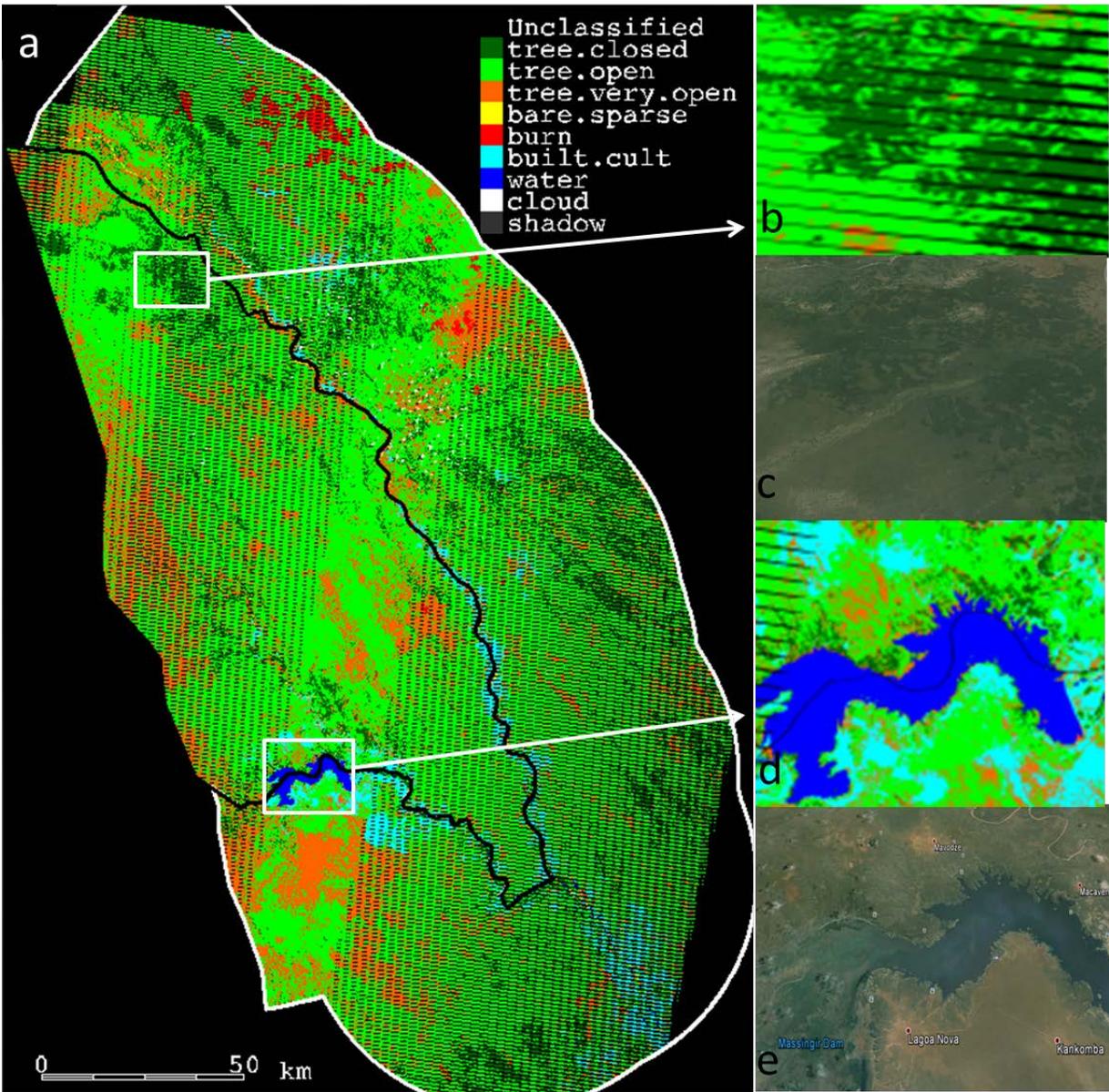
Using VHR imagery available at Google Earth and Co-I Silva’s in situ photographs and knowledge of Mozambican landscape, we have developed a land cover mapping legend including 9 general classes: 1) tree closed (crown cover 80-100%), 2) tree open (crown cover 50-80%), 3) tree very open (crown cover 10 – 50%), 4) bare and sparsely vegetated, 5) recent burns, 6) built up and cultivated (the majority of built areas do not contain impervious surfaces and thus are spectrally indistinguishable from bare soil), 7) water, 8) cloud, 9) shadow. Using dry and wet season mosaics from 2007 we have tested and implemented land cover classification and subsequent analysis of land cover within the outside the GLTP (Figures 1 and 2). The results show that in 2007 (five years after the establishment of the GLTP) land cover composition differs within and outside the GLTP boundaries. As expected the amount of built and cultivated lands within the GLTP park is considerably lower than in the 50 km buffer outside the GLTP (~25% of the total built and cultivated areas). It is worth noting that the total area within the park is smaller ~50% of the area in the buffer outside the park. However, even in relative terms (percent from the total area of the park or buffer zones) built and cultivated lands are twice as likely to be encountered outside the part that within the GLTP. More striking is the difference in the amount of burning within and outside the park. There was only one small burn scar in the northern section of the GLTP whereas we found 25 times more burned area outside the GLTP

**Table 1. Landsat scenes acquired for multi-temporal mapping of land cover and change analysis**

| year | p168r76 |     |     |     |     |     |     |     |     |     | p168r77 |     |     |     |     |     |     | p169r76 |     |     |     |     |     |     |     |     |     |
|------|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|-----|-----|-----|-----|-----|-----|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|      | Wet     |     |     |     |     | Dry |     |     |     |     | Wet     |     |     |     | Dry |     |     | Wet     |     |     |     | Dry |     |     |     |     |     |
|      | Mar     | Apr | May | Jun | Aug | Sep | Oct | Nov | Dec | Mar | Apr     | May | Jun | Aug | Sep | Oct | Nov | Dec     | Mar | Apr | May | Jun | Aug | Sep | Oct | Nov | Dec |
| 1984 |         |     |     |     | 240 |     |     |     |     |     |         |     |     | 240 |     |     |     | 352     |     |     |     |     |     | 274 |     |     |     |
| 1985 |         |     |     |     |     |     |     |     |     |     |         |     |     |     |     |     |     |         |     |     |     |     |     |     |     |     |     |
| 1986 |         |     |     |     |     |     |     |     | 357 |     |         |     |     |     |     |     |     |         |     | 140 |     |     |     |     |     | 316 |     |
| 1987 | 72      |     |     |     |     |     |     |     |     | 72  |         |     |     |     |     |     |     |         |     |     |     |     |     |     |     |     |     |
| 1988 |         |     |     |     |     |     |     |     |     |     |         |     |     |     |     |     |     |         |     |     |     | 154 |     |     |     |     |     |
| 1989 |         |     |     |     |     | 253 |     |     |     |     |         |     |     |     |     |     |     |         |     | 132 |     |     | 260 |     |     |     |     |
| 1990 |         |     |     | 160 |     |     | 288 |     |     |     |         | 144 |     |     |     | 304 |     |         |     |     | 167 |     |     | 295 |     |     |     |
| 1991 |         |     | 147 |     |     | 259 |     | 323 |     |     | 147     |     |     | 259 |     |     |     |         |     | 122 |     |     |     |     | 314 |     |     |
| 1992 |         |     |     | 182 |     |     | 294 |     |     |     |         |     |     |     | 294 |     |     |         |     |     | 173 |     | 277 |     | 317 |     |     |
| 1993 |         |     | 136 |     |     | 264 |     |     |     |     | 136     |     |     | 264 |     |     |     |         |     | 127 |     |     |     |     |     |     | 335 |
| 1994 |         |     |     |     |     |     |     | 331 |     |     |         |     | 219 | 267 |     |     | 347 |         |     |     |     | 226 |     | 290 |     |     |     |
| 1995 |         |     |     | 174 |     | 270 |     |     |     |     |         | 174 |     | 270 |     |     |     |         |     |     | 181 |     |     |     |     |     |     |
| 1996 |         |     |     |     |     |     |     |     |     |     |         |     |     |     |     |     |     |         |     |     |     |     |     |     |     |     | 360 |
| 1997 |         | 99  |     |     |     | 259 |     |     |     | 83  |         |     |     | 259 |     |     |     |         |     | 122 |     |     | 250 |     |     |     |     |
| 1998 |         |     | 150 |     |     |     | 278 |     |     |     | 150     |     |     |     | 278 |     |     |         |     | 141 |     |     |     | 301 |     |     |     |
| 1999 |         |     |     |     |     |     |     | 321 |     |     |         |     |     |     | 289 |     |     |         |     |     |     |     |     |     | 312 |     |     |
| 2000 |         | 100 |     |     |     | 292 |     |     |     | 100 |         |     |     |     |     |     |     |         |     |     | 155 |     |     |     | 315 |     |     |
| 2001 |         | 118 |     |     | 230 |     |     |     |     |     | 150     |     |     |     | 278 |     |     |         |     | 141 |     |     | 253 |     |     |     |     |
| 2002 |         |     | 137 |     |     | 265 |     |     |     |     |         |     |     |     | 297 |     |     |         |     | 128 |     |     | 272 |     |     |     |     |
| 2003 |         |     | 124 |     |     |     |     | 348 |     |     | 124     |     |     |     |     |     | 324 |         |     | 99  |     |     |     |     |     |     | 355 |
| 2004 |         |     | 143 |     | 223 |     |     | 319 |     |     | 127     |     |     |     |     |     | 319 |         |     |     | 134 |     |     | 278 |     |     |     |
| 2005 |         |     |     | 177 |     |     |     | 305 |     |     |         | 177 |     |     |     | 305 |     |         |     |     | 152 |     | 264 |     | 320 |     |     |
| 2006 |         |     | 132 |     |     | 260 |     |     |     |     | 148     |     |     |     |     |     | 348 |         |     |     |     |     |     | 299 |     |     |     |
| 2007 |         |     | 135 |     |     |     | 263 |     |     |     | 135     |     |     | 263 |     |     |     |         |     | 142 |     |     |     | 286 |     |     |     |
| 2008 |         | 98  |     | 186 |     |     |     | 330 |     |     | 122     |     |     |     |     | 330 |     |         |     | 113 |     | 241 | 249 |     |     |     |     |
| 2009 |         |     | 132 |     |     |     |     |     |     |     | 132     |     |     |     |     |     |     |         |     | 115 | 139 |     |     |     |     | 331 |     |
| 2010 |         | 119 |     |     | 239 | 255 |     |     |     |     |         | 159 |     |     |     |     |     |         |     |     | 126 |     |     | 294 |     |     |     |
| 2011 |         |     | 131 |     | 242 |     |     | 322 |     |     |         | 178 |     |     |     |     |     |         |     |     |     |     |     |     |     |     | 281 |

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spread out near populated areas. This finding strongly suggests that fires in this region are primarily of anthropogenic origin and can be controlled and minimized through targeted policies and enforcement.



**Figure 1. 2007 land cover map a) within (outlined in black) and outside (50 km buffer outlined in white) the GLTP. Insets b and c show detail in land cover classification with corresponding VHR true color images available in Google Earth (c and e, respectively).**

The majority (> 90%) of area in and around the park remains within some form of tree dominated communities, although the proportion within the park is greater (97% within vs. 92% outside the park). Distribution of built and cultivated landscapes is closely linked to the presence of water, specifically rivers, within and outside the park. Overall, while the trends in development and land cover composition appear to differ within and outside the park, we will be

able to ascertain whether park establishment has played a role in shaping those differences or reversing previous trends only upon completing the multi-year analysis of change.

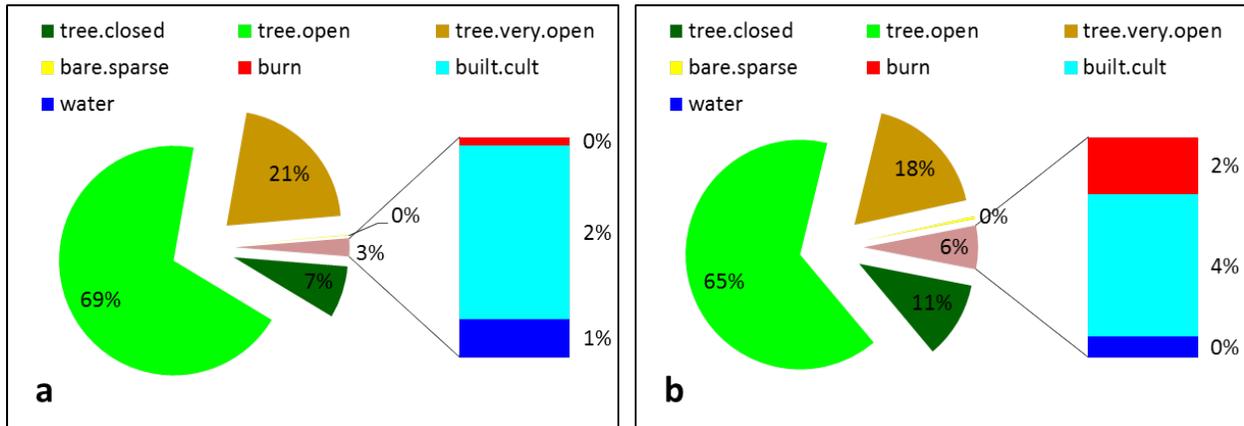


Figure 2. Relative composition of land cover a) within and b) outside the GLTP in 2007.

*Very High Resolution data archive for mapping and characterizing village properties*

In parallel with the Landsat-scale mapping activities we have begun development of the archive of available VHR data from commercial satellite in support of detailed characterization of village structure in Mozambique. Table 2 lists the scenes we have obtained to initialize the development of mapping techniques. The acquired imagery will be reprocessed to convert digital numbers to the top of atmosphere reflectance prior to image analysis. The obtained imagery corresponds to the time period of socio-economic surveys conducted by Co-I Silva and is thus representative of specific changes noted in the surveys. Additional imagery pre-dating the establishment of the park in 2002 will be obtained at a later date.

Table 2. Very High Resolution imagery within and outside the GLTP acquired for village characterization.

| Date          | Sensor     | Scene ID  |
|---------------|------------|---|
| Aug. 20, 2008 | WorldView1 | 20AUG08WV010600008AUG20080816-P1BS-052108011010_01_P018     |
|               |            | 20AUG08WV010600008AUG20080816-P1BS-052126355010_01_P012     |
|               |            | 20AUG08WV010600008AUG20080816-P1BS-052400000010_01_P020     |
| Jan. 25, 2009 | WorldView1 | 25JAN09WV010600009JAN25081316-P1BS-052126355010_02_P001     |
| Feb. 11, 2009 | WorldView1 | 11FEB09WV010600009FEB11081355-P1BS-052126355010_02_P011     |
|               |            | 11FEB09WV010600009FEB11081356-P1BS-052055243010_04_P002     |
| Sep. 16, 2009 | WorldView1 | 16SEP09WV010600009SEP16081811-P1BS-052126355010_02_P008     |
|               |            | 16SEP09WV010600009SEP16081812-P1BS-052126355010_02_P009     |
| Nov. 09, 2009 | OrbView5   | 09NOV10OV05010005V101109M0010031914A222008801172M_000481057 |
|               |            | 09NOV10OV05010005V101109P0010031914A222035204682M_000481057 |
| June 12, 2011 | WorldView1 | 12JUN11WV010600011JUN12082026-P1BS-052442630010_06_P007     |
|               |            | 12JUN11WV010600011JUN12082026-P1BS-052442630010_06_P008     |
| Oct. 22, 2011 | WorldView1 | 22OCT11WV010600011OCT22081533-P1BS-052592637010_03_P001     |
| Feb. 03, 2012 | WorldView2 | 03FEB12WV020700012FEB03081158-M1BS-052648384010_01_P009     |
|               |            | 03FEB12WV020700012FEB03081158-P1BS-052648384010_01_P009     |
|               |            | 03FEB12WV020700012FEB03081159-M1BS-052648380010_01_P001     |
|               |            | 03FEB12WV020700012FEB03081159-M1BS-052648384010_01_P010     |

|                      |            |  |
|----------------------|------------|--|
|                      |            | 03FEB12WV020700012FEB03081159-P1BS-052648380010_01_P001<br>03FEB12WV020700012FEB03081159-P1BS-052648384010_01_P010   |
| <b>Apr. 19, 2012</b> | WorldView2 | 19APR12WV020600012APR19081341-M1BS-052648380010_01_P002<br>19APR12WV020600012APR19081341-P1BS-052592637010_06_P010<br>19APR12WV020600012APR19081341-P1BS-052648380010_01_P002  |
| <b>May 27, 2012</b>  | WorldView2 | 27MAY12WV020600012MAY27081352-M1BS-052648380010_03_P009<br>27MAY12WV020600012MAY27081352-P1BS-052592637010_07_P009<br>27MAY12WV020600012MAY27081352-P1BS-052648380010_03_P009  |
| <b>July 16, 2012</b> | WorldView1 | 16JUL12WV010600012JUL16081226-P1BS-052648384010_06_P009<br>16JUL12WV010600012JUL16081235-P1BS-052648380010_06_P001   |
| <b>Sep. 10, 2012</b> | QuickBird  | 10SEP12QB020600012SEP10072832-M1BS-052869963100_01_P009<br>10SEP12QB020600012SEP10072832-P1BS-052869963100_01_P009<br>10SEP12QB020600012SEP10072835-M1BS-052869963100_01_P010<br>10SEP12QB020600012SEP10072835-P1BS-052869963100_01_P010 |
| <b>Nov. 16, 2012</b> | WorldView2 | 16NOV12WV020600012NOV16083526-M1BS-052894152010_01_P009<br>16NOV12WV020600012NOV16083526-M1BS-052894152010_01_P010<br>16NOV12WV020600012NOV16083526-P1BS-052894152010_01_P009<br>16NOV12WV020600012NOV16083526-P1BS-052894152010_01_P010 |

*Compilation and analysis of socio-economic data from household and village surveys*

We have successfully completed the Internal Review Board (IRB) application and have been granted permission to conduct socio-economic surveys with human subjects in designated locations within and outside the GLTP. During the first year of the grant we have begun analyzing existing data collected from previous field campaigns. These data include 1) spatially referenced data on household location, roads, physical infrastructure, natural resource access points, and areas with high incidences of human-wildlife conflict; 2) 375 household socio-economic survey data (a census of all households in the area, 85% response rate) collected in 2009; and 3) 160 in-depth follow-up interviews with original survey respondents conducted in 2012. The GIS data are used to develop a base layer in support of detailed analysis within the case study areas. The socio-economic data analysis is being conducted in SAS to construct community profiles with geospatial linkages to the base GIS maps. We have built community profiles with these data to better contextualize the economic livelihoods, self-reported resource use, and resident attitudes regarding park policies in the case study sites. We are currently using NVIVO software to open code interview transcriptions, field notes, and participation observation notes, moving from multiple concepts to broader themes (Corbin and Strauss 2007). We employ a conventional strategy in which categories are derived directly from the data (Hsieh and Shannon 2005). These analysis will be used to guide the design survey and focus group interview instruments for qualitative data collection that will take place in the summer of 2014.

**Work schedule for 2014:**

During 2014 we will focus on completing the multi-temporal Landsat-scale analysis of land cover change and grassland productivity as a function of park presence in Mozambique. We are also planning to conduct the field verification and socio-economic data survey during the summer field season. Finally, we will start developing approaches to characterize village structure from VHR imagery.

- January – June 2014: Finalize the Landsat-based land cover mapping 1984-2011. Design socio-economic survey, interview, and focus group instruments.
- June – August 2014: Field socio-economic data survey and map verification.
- May - October 2014: VHR-based village structure characterization.
- May – December 2014: Analysis of LCLUC patterns and the local perceptions of park impact on livelihoods.
- October – December 2014: Manuscript development detailing long-term changes in land cover composition and state in the GLTP as a function of park establishment.

## References:

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- Hsieh, H. and S.E. Shannon, 2005. The Approaches to Qualitative Content Analysis, *Qualitative Health Research*, 15, 1277-88.
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