SUITABILITY MAPPER TECHNICAL DOCUMENT

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Introduction

The Suitability Mapper enables users to identify potentially suitable sites for sustainable palm oil production. The World Resources Institute (WRI) and Sekala developed this publically available online application to allow users to replicate or customize the desktop portion of a method developed under Project POTICO for identifying potentially suitable areas for sustainable palm oil in Indonesia, and to identify priority sites for further investigation in the field.

In Indonesia, there is wide-spread support from the national government and palm oil industry leaders to develop policies and practices that promote sustainable oil palm plantation expansion on low-carbon, degraded land. However, there is a lack of common data and definitions to support such strategies, including the absence of a comprehensive methodology for identifying "degraded land" that is potentially suitable for oil palm plantation development. This method was designed in accordance with established standards for sustainable palm oil production. It incorporates relevant Indonesian laws and policies, and is consistent with Indonesia's proposed national REDD+ strategy to support palm oil production on degraded land.

The Suitability Mapper can be used by a wide variety of stakeholders for a range of potential applications, such as Indonesian government officials assessing policy options to support palm oil production on degraded land and palm oil producers committed to certification standards, such as those of the Roundtable on Sustainable Palm Oil (RSPO). While this initial version was designed to address specific questions facing the palm oil industry and is limited geographically to Kalimantan (Indonesian Borneo), we look forward to working with you to expand its uses and impact.

This document is designed to help you understand how to use the Suitability Mapper and the technical aspects of how it works. The following sections include: 1) Overview of Functions and Limitations, 2) How-to-use Guidance, 3) Methodology, 4) Data and Specifications. Please Contact Us[i] to help us improve your experience with the Suitability Mapper, get more information, inquire about training sessions, contribute case studies, share data, or provide general feedback.

Note: The data used in this application varies in quality and has not been systematically verified. Field assessments and other due diligence activities are required to confirm or reject the suitability of a site. Please see Disclaimer at the end of this document.

Overview of Functions and Limitations

The Suitability Mapper allows you to do three basic things:

1) **Customize and view a Suitability Map**

   - Identify potentially suitable areas for sustainable oil palm cultivation on a Suitability Map created using the default settings determined by Project POTICO. These default environmental and crop criteria settings are based on the desktop portion of the methodology developed by WRI and Sekala, detailed in the publication [How to Identify Degraded Land for Sustainable Palm Oil in Indonesia](#).

   - Identify potentially suitable areas for oil palm cultivation on a Suitability Map customized according to settings determined by you, the user. Adjust settings for environmental and crop criteria to create a customized Suitability Map based on your own project-specific needs or research interests.

2) **Overlay and compare maps**

   - Compare your Suitability Map to other relevant maps of Kalimantan. View maps for each of the individual datasets used to create the suitability map and additional maps related to legal and social criteria not included in the suitability map analysis. Overlay your suitability map with any of these maps for comparison, or with the Oil palm suitability default map created using the default settings.

3) **Select and analyze specific sites of interest**

   - Select one or more sites for analysis by zooming, drawing, or uploading a shape file. View detailed information about a site that might impact its potential for development, including the site's total area, potentially suitable area, distance to nearest road, legal classification, and existing concessions. This information can be used to guide field assessments of these areas to confirm or reject their suitability for a specific project.

   - View summary results of your suitability analysis broken down by districts and provinces. This information can be used to inform discussions with policy-makers.

The Suitability Mapper has some limitations, some that are inherent to a large-scale desktop analysis, and some that we are working to address by continuing to work with stakeholders and partners:

Table 1. Application limitations and steps to address

Limitation	Steps to Address
The reliability of the suitability map is limited by the accuracy of the data used.	Field assessments are necessary to determine the accuracy of map results. Data used in the Suitability Mapper will be updated and improved as it becomes available.We welcome your ideas on improved data that can be included.
Complex legal and social issues may impact the development potential of the suitable areas identified with the Suitability Mapper.	Site-level due diligence to address potential legal and social issues is imperative prior to initiating development projects. These activities, such as social impact assessments and implementing a comprehensive process for obtaining free, prior, and informed consent (FPIC), are beyond the scope of the Suitability Mapper. A first step would be to conduct rapid field assessments, as described in the Working Paper "How to Identify Degraded Land for Sustainable Palm Oil in Indonesia." WRI is conducting research on relevant social and legal issues to provide additional "how to" guidance to companies.
Default suitability settings are limited to oil palm.	Although default settings are only provided for oil palm, users familiar with the requirements of other crops can adjust the suitability settings appropriately by changing the settings in the Crop Criteria tab. The Suitability Mapper was initially developed with a focus on oil palm. WRI intends to explore additional considerations that may be associated with other crops.
Analysis is limited to Kalimantan.	The Suitability Mapper was originally developed for Kalimantan and is currently under development for Papua, with the aim to develop the tool for all of Indonesia, as well as other palm oil producing countries.

How-to-use Guidance

This section describes how to use all the functions of the Suitability Mapper.

Upon opening the Suitability Mapper, navigate through the welcome screen to view the web tool interface. The screen displays a map of Indonesia highlighting Kalimantan. Zoom in or out to focus on different parts of the map. Click and drag to move the focus of the map.

Map Controls

The "Map Controls" panel in the upper right-hand corner of the screen provides tools for viewing maps, customizing a suitability map, and selecting field sites for further investigation. The tools are divided among three tabs, "Explore Maps," "Set Suitability," and "Select Sites."

1) **Explore Maps** allows you to view your current suitability map as well as additional maps of Kalimantan. You can also overlay your current suitability map onto any of the other maps. The "Explore Maps" tab has the following controls:

   - **Suitability Map:** Select to view map showing potentially suitable and not suitable areas according to the criteria selected in Set Suitability.
     - **Transparency:** Adjust the slider bar to make your suitability map more or less transparent over the base map or over another map selected in "More Maps".
     - **Reset Defaults:** Select to return to the oil palm suitability default settings selected under Project POTICO if you have made changes in the "Set Suitability" tab.

   - **More Maps:** Select to view additional maps of Kalimantan. To view your Suitability Map overlaid with any of the maps in More Maps, check both the More Maps box and the Suitability Map box, and adjust the transparency slide bar. Table 2 describes the viewable maps (for full data citations, see "Data" section of this document.

   - You can overlay your selected maps with several other map features:
     - **Political boundaries**: Select to display the districts and provinces of Kalimantan
     - **Roads**: Select to show detailed roads, including logging roads.
     - **Rivers:** Select to show rivers
     - **Settlements:** Select to show the main cities of Kalimantan.
     - **Case Studies:** This is under development. We are currently seeking case studies that demonstrate how the Suitability Mapper has been used. In the future, you will be able to select to

pinpoint case study locations, showing examples of where the Suitability Mapper has been used for real-world applications.

- ▪ **Contribute Case Study:** Select if you have a case study you would like to share or would like more information about working with us to conduct a case study. This link will direct you to our to our "Contact Us" feedback form.

Table 2. Viewable Maps in More Maps

Map Title	Description
Oil Palm Suitability Default	This default suitability map reflects the values selected under Project POTICO for the purpose of identifying potentially suitable areas for sustainable palm oil production to be further investigated through field assessments (WRI, 2012).[ii]
Land Cover	Land cover in 2006, classified by type. The data is sourced from 2009 Ministry of Forestry data (Ministry of Forestry, 2009, 1:250,000 scale). [iii]
Peat Depth	Peat land in Kalimantan, classified by depth (Wetlands International 2004, 1:250,000 scale).
Conservation Areas	Legally defined conservation areas, based on data and classifications from the Ministry of Forestry (Ministry of Forestry, year unknown, 1:250,000 scale).
Elevation	Elevation, in meters (SRTM, 2008, 90 m resolution).
Slope	Slope, in percent (SRTM, 2008, 90 m resolution).[iv]
Rainfall	Mean rainfall (in mm) for the period of 1989 to 2009 (WorldClim Global Climate data, 1989-2009, 1000 m resolution).
Soil Drainage	Soil drainage, classified according to descriptive categories (RePPProT, 1990, 1:250,000 scale)[v]
Soil Depth	Soil depth, classified into descriptive and numerical depth categories (RePPProT, 1990, 1:250,000 scale)[vi]
Soil Acidity	Soil acidity, classified into pH classes (RePPProT, 1990, 1:250,000 scale)
Soil Type	Soil type, classified according to FAO Soil categories (RePPProT, 1990, 1:250,000 scale). [vii]
Legal Classification	Legal classifications, based on Ministry of Forestry categories (Ministry of Forestry, year unknown, 1:250,000 scale): convertible production forest (HPK), limited production forest (HPT), non-forestland (APL), production forest (HP), protection forest (HL), conservation forest (KSA-KPA)
Concessions	Logging, timber, and estate crop concessions from the Ministry of Forestry (Ministry of Forestry, year unknown).
Population Density	Population density per scare kilometer (CIESIN, 2009).[viii]
Tree Cover Loss 2001-2010	Tree cover loss to <30% canopy cover for each year 2000-2010 (Hansen, M., 2012, 60 m resolution). [ix]

2) **Set Suitability**: Customize your suitability map by making changes to the individual criteria used in the suitability analysis. Adjust the range of values/categories that are classified as potentially suitable (purple) versus Not Suitable (yellow) for each criterion.

The "Set Suitability" tab is divided into two sub-tabs with different categories of criteria, "Environmental Criteria", and "Crop Criteria":

- **Environmental Criteria** includes five individual criteria:
    i. **Land Cover:** Click on the circle next to each land cover type to set as potential (purple) or Not Suitable (yellow). The land cover types listed (grassland/shrub, plantations, agriculture, settlements/other land use, secondary forest, primary forest, wetland) are a simplified reclassification of Ministry of Forestry land cover classes (see "Data" section for details).
    ii. **Peat depth:** Move the slider to select the maximum peat depth, (in centimeters) classified as potential (purple), from 0 to 1,000 centimeters.
    iii. **Conservation area buffers:** Move the slider to set the minimum buffer zone distance (in meters) around conservation areas, to be classified as not suitable (yellow), ranging from 500 to 5,000 meters.
    iv. **Water resource buffers:** Move the slider to set the minimum buffer zone distance (in meters) around water resources, to be classified as not suitable (yellow), ranging from 50 to 1,000 meters.
    v. **Slope:** Move the slider to set the maximum slope (in percent) to be considered potential (purple), from 0-80 percent.

- **Crop Criteria** includes six individual criteria
    i. **Elevation:** Move the slider to set the maximum elevation (in meters) to be classified as potential (purple), ranging from 0 to 2,300 meters.
    ii. **Rainfall:** Move the sliders to set a range (minimum and maximum) for the annual level of rainfall (in millimeters/year) to be considered potential (purple)
    iii. **Soil drainage:** Move the sliders to set a range (minimum and maximum) for the level of soil drainage to be considered potential (purple).
    iv. **Soil depth:** Move the slider to set the minimum soil depth (in centimeters) to be classified as potential (purple).

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v. **Soil acidity:** Move the sliders to set the range (minimum and maximum) of soil acidity (pH) to be considered potential (purple).

vi. **Soil type:** Click on the circle next to each soil type to set as potential (purple) or not suitable (yellow). Soil types listed include inceptisol, oxisol, alfisol, ultisol, spodosol, entisol, histosol.

- **Reset Defaults:** Select to return to the oil palm suitability default settings selected under Project POTICO

3) **Select Sites:** Analyze potential sites for field assessments by drawing or uploading them on the map. Click on a shape you have created to display its total area, its area of potentially suitable land and the Details button. Open **Details** to view analysis results including distance to nearest road, legal classifications, and existing concessions.

- **Zoom to:** Find an area for analysis by entering the geographic coordinates for a location in Kalimantan, then selecting "Go" to zoom to that area
- **Select a shape:** Select **Circle** or **Rectangle** to quickly draw an area for analysis. Click on the map to begin drawing and let go to finish. Use **Polygon** to draw a more detailed shape. Click on the map to start drawing, click again to define corners, and double click to complete the polygon. Select **Upload** to upload a shapefile containing your sites of interest. Select **clear all** to remove all shapes that you have drawn or uploaded from the map. Note that this will permanently remove the shapes. Shapes that you have drawn or uploaded will not be saved to the website.

Suitability Results

The "Suitability Results" tab at the bottom of your screen provides a summary display of your suitability analysis results, organized by provinces, districts, or sites you've selected in the "Select Sites" tab.

Select either "Provinces", "Districts", or "My Sites" from the drop down menu at the top of the table. Use the **update** button to update results whenever you make changes in the "Set Suitability" tab.

Suitability results will appear, displaying the potential and not suitable areas in hectares within each province, district, or site, depending on your selection. Click on the heading of any of the three result columns to arrange the results from lowest to highest or highest to lowest for that column. Select **Export** to download the summary results into an Excel spreadsheet. **Note: The data used to generate these results has not been systematically verified and therefore field assessments are necessary to confirm or reject the suitability of each site. ˣ**

Legend

The Legend box on the bottom right of the screen provides the legend to the map and changes as different layers are added and removed. Click on the **Sources** button in the upper-right hand corner to view a detailed description of the sources used.

Map Tools

The Map Tools box on the left of the screen includes several tools:

- **Overview:** allows you to see where the map is focused in relation to the rest of the Eastern Hemisphere.
- **Print:** allows you to name and print the current map.
- **Draw:** toolbar allows you to draw shapes and label important features directly onto the map:
  - o **Point**: allows you to draw dots on the map to highlight areas of interest. Click on the point button and then move the cursor to the place on the map where you want to place a dot. Click the mouse once and a dot will appear.
  - o **Line**: allows you to draw a straight line.
  - o **Free line**: allows you to draw a line in any shape and direction.
  - o **Rectangle:** allows you to create a rectangle or square of any size on the map.
  - o **Polygon:** allows you to create a shape with multiple sides. Click and pull the line as many times as needed, and then double click to finish the object.
  - o **Move**: allows you to move any drawn object by clicking and dragging the object.
  - o **Eraser:** allows you to delete individual objects that you have drawn on the map.
  - o **Clear all**: allows you to delete all objects that you have drawn on the map at once.

Banner

The banner on the top of the screen has three purposes:

- The **Basemap** button on the right allows you to choose between different base maps: topographical, a street map, satellite, and a Landsat 2010 map.
- The **English** and **Bahasa Indonesia** radio buttons will allow you to change languages once the Bahasa Indonesia version is available.
- The buttons on the left allow you to navigate away from the Suitability Mapper. The **About** button takes you to the about page for the Forest Cover Analyzer on the WRI website. The **Contact Us** button takes you to our feedback form. The **Download Data** button allows you to download the data that is available.

For more help navigating the Suitability Mapper, a tutorial is under development and will be made available on the About page.

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Methodology

The method used to develop the Suitability Mapper was adapted from the WRI-Sekala working paper, [How to Identify Degraded Land for Sustainable Palm Oil in Indonesia](#). The "Oil Palm Suitability Default" map reflects the suitability settings selected under Project POTICO, which are consistent with the standards of the Roundtable on Sustainable Palm Oil (RSPO), relevant Indonesian laws, and proposed national policies to support palm oil production on low carbon "degraded land."

The Suitability Mapper assigns all land to one of two suitability classes, potential or not suitable. Potential suitability is determined by 11 individual indicators. To create the suitability map, the two suitability classes are each assigned a number code, in which potential = 1, and not suitable = 0.[xi] Each code is assigned to a specific range of values for each indicator in the analysis.   For example, for the indicator of elevation, a value of less than 1,000 meters is potential (1), and a value of greater than 1,000 meters is not suitable (2). A simple binary technique is used to determine the overall suitability of an area, such that if the value of any single indicator for an area is not suitable, the end result for that area is not suitable.[xii] Conversely, for an area to be classified as potential, values for all 11 indicators in that area must be potential.

The resulting suitability map is the combination of two types of indicators: environmental criteria and crop criteria.

<u>**Environmental criteria**</u> are designed to reflect whether land can likely be considered suitable based on carbon stocks, biodiversity high conservation values (HCV 1–3),[xiii] and soil and water protection values. This layer has five suitability indicators: (1) land cover, (2) peat, (3) slope, (4) conservation area buffer, and (5) water resource buffers.

- **Land cover:** refers to whatever is covering the earth's surface, whether the cover is a class of vegetation or a type of manmade infrastructure. It serves as an indicator for above ground carbon stocks and biodiversity. Land cover also serves as a preliminary indicator for land use and soil and water protection.The default categories are those that can be described as "degraded land" in the sense of being likely to have low carbon and/or low levels of biodiversity, as is consistent with RSPO Principles and Criteria and Indonesia's proposed REDD+ strategies (See Table 3 for default values).

- **Peat depth:** Due to their high carbon content, peat soils of any depth are considered not suitable for oil palm plantations according to the draft Indonesia REDD+ strategy and according to Presidential Instruction No 10/2011 regarding a two-year moratorium on new permits on primary natural forest and peatland (See Table 3). Three earlier laws have restricted development of land with peat soils deeper than three meters:

Ministry of Agriculture Regulation 14/2009, Presidential Decree 32/1990, and Government Regulation 26/2008. Peat soils are also associated with critical hydrological function and soil and water protection.

- **Conservation area buffers:** Conservation areas are likely to contain biodiversity high conservation values (HCV 1 – 3) and are defined by legal classifications from the Ministry of Forestry, with default buffer zones created in accordance with Indonesian regulations, namely Government Regulation No. 47/1997 and Presidential Decree No. 32/1990 (See Table 3). Any area within a conservation area or buffer zone is classified as not suitable for oil palm expansion.

- **Water resource buffers:** Water resource buffers are areas surrounding water resources – including lakes, streams, rivers, springs, and coastlines – that are critical for maintaining healthy water supply. The default setting was chosen as consistent with Indonesian Government Regulation No. 47/1997 and Presidential Decree No. 32/1990 (See Table 3).

- **Slope**: Slope is included in environmental criteria because it is an important factor in determining erosion risk. Minimizing erosion by avoiding high slopes contributes to soil and water protection. Slope is also an important factor in crop productivity. The default value was defined based on a review of several existing standards[xiv] (See Table 3).

Table 3. Default Suitability Values for Environmental Criteria

Indicator	Suitability Classes	
	Potential	**Not Suitable**
Land cover	Grassland/shrub; Plantations; Agriculture; Settlements/other uses	Primary forest; Secondary forest; Wetland
Peat	0 cm	Any value > 0 cm
Slope	0-30 percent	>30 percent
Conservation area buffer	>1000 m	<1000 m
Water resource buffer	>100 m	<100 m

<u>Crop Criteria</u> are designed to reflect whether land is suitable for the successful cultivation for oil palm plants. This layer has six indicators: (1) **elevation**, (2) **rainfall**, (3) **soil drainage**, (4) **soil depth**, (5) **soil acidity**, and (6) **soil type**. These indicators are important economic factors impacting crop yields, the amount of management input required (that is, fertilizer, specialized crop strains, irrigation, terracing), and the long-term profitability of a plantation. For these indicators, appropriate suitability classes may vary according to individual company or project-specific requirements. Suitability classes could also be adjusted to identify potentially suitable sites for other crop types.

Default values for the crop criteria were defined using a compilation of existing standards identified from the Roundtable on Sustainable Palm Oil (RSPO),[xv] ISRIC World Soil Information,[xvi] Regional Physical Planning Programme for Transmigration (RePPProT),[xvii] and SarVision[xviii] (See Table 4 for values). Of these, the standard with the most inclusive range of suitability is selected for most indicators. This allows for the widest range of potentially suitable areas, including areas that may require higher levels of management input and technology. The decision to select the most inclusive suitability ranges is based partly on feedback from palm oil companies, which indicates that current market trends and technological advances make it increasingly feasible to cultivate under less than ideal biophysical conditions.

Table 4: Default Suitability Values for Crop Criteria

Indicator	Suitability class	
	Potential	**Not Suitable**
Elevation	0-1000 m	>1000 m
Rainfall	1250-6000 mm/yr	>6000mm/yr; <1250mm/yr
Soil depth	Moderately deep (51-75 cm), Deep (76-100 cm), Very deep (101-150 cm), Extremely deep (>150 cm)	Very shallow (0-10 cm), Moderately shallow (26-50 cm)
Soil type	Inceptisol; Oxisol; Alfisol; Ultisol; Spodosol; Entisol	Histosol
Soil drainage	Good; moderately good; excessive; poor	Very excessive; very poor; stagnant
Soil acidity	Excessively acid (<4.0), Extremely acid (4.0-4.5), Very strongly acid (4.6-5.0), Strongly acid (5.1-5.5), Moderately acid (5.6-6.0), Slightly acid (6.1-6.5), Neutral (6.6-7.3)	Basic (>7.3)

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Data and Specifications

In developing the Suitability Mapper, WRI aimed to maintain the highest standard of quality possible in terms of ease of use, accuracy of data, accessibility of data, and the manipulations and algorithms that present the data.

Ease of Use

- The Suitability Mapper is intended for use by a general audience with no prior knowledge of GIS software or other technical expertise.
- To ensure a positive user experience, the Suitability Mapper went through an extensive internal review process, drawing on feedback from over 100 stakeholders.
- The Suitability Mapper can be accessed at http://www.wri.org/applications/maps/suitability-mapper/index.html by anyone with an internet connection and a web browser (e.g. Internet Explorer, Firefox, Google Chrome) . It requires Adobe Flash Player which can be downloaded for free here: http://get.adobe.com/flashplayer/.

Accuracy of Data

- The data used in the Suitability Mapper varies in accuracy, completeness, and resolution. It has not been systematically verified.
- **Therefore, field assessments are necessary to confirm or reject any results generated by the Suitability Mapper.**
- The Suitability Mapper utilizes land cover data provided by the Ministry of Forestry. This dataset was chosen due to Indonesian Government Regulation No. 4 / 2011, article 22 and 23, which states that basic geospatial information can only be provided by the Indonesian government. Although more recent data is available, this is the data that is most accepted by government officials.

Accessibility of Data

- All available information about sources and methods for each dataset is included below as well as in the metadata of the downloadable data.
- Datasets used in the Suitability Mapper are publically available for download here.[1]

Manipulations and Algorithms

- The method that the Suitability Mapper is based on was developed in consultation with other leading NGOs and was peer-reviewed through an internal and external review process and published in a WRI/Sekala Working Paper.
- The applications are written using Adobe Flex which is an open source framework for building applications for the browser, desktop and mobile devices.
- The results of the Suitability Mapper were verified by manually comparing the Oil Palm Suitability Default map generated using ArcGIS and the Suitability Map generated by the Suitability Mapper using the default settings.

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[1] http://www.wri.org/project/potico/about-suitability-mapper

Table 5: Data Descriptions and Sources

Title	Description	Sources
Oil Palm Suitability Default	Shows potentially suitable areas for sustainable oil palm cultivation, according to the default settings determined by Project POTICO. These default environmental and crop criteria settings are based on the methodology developed by WRI and Sekala, detailed in Gingold et al. (2012), available online at http://www.wri.org/publication/identifying-degraded-land-sustainable-palm-oil-indonesia. Suitability calculated using the following default values: • Land cover - Suitable: grassland/shrub; plantations; agriculture; settlements/other uses. Not suitable: primary forest; secondary forest, wetland • Peat depth – Suitable :0 cm. Not suitable: any value > 0 cm • Slope – Suitable: 0-30%. Not suitable : >30% • Conservation area buffer – Suitable: >1000 m. Not suitable: <1000m • Water resource buffer – Suitable: > 100 m. Not suitable: <100 m • Elevation – Suitable: 0-1000m. Not suitable: >1000 m • Rainfall – Suitable: 1250-6000mm/yr. Not suitable: >6000mm/yr; <1250mm/yr • Soil drainage – Suitable: good; moderately good; excessive; poor. Not suitable: very excessive; very poor; stagnant • Soil depth – Suitable: moderately deep (51-75 cm); deep (76-100 cm); very deep (101-150 cm); extremely deep (>150 cm). Not suitable: very shallow (0-10 cm); moderately shallow (26-50 cm) • Soil acidity (pH) – Suitable: excessively acid (<4.0); extremely acid (4.0-4.5); very strongly acid (4.6-5.0); strongly acid (5.1-5.5); moderately acid (5.6-6.0); slightly acid (6.1-6.5); neutral (6.6-7.3). Not suitable: none. • Soil type – Suitable: Inceptisol; Oxisol; Alfisol; Ultisol; Spodosol; Entisol. Not suitable: Histosol	World Resources Institute (2012).
Land Cover	This layer shows 2006 land cover, classified by type. The data is sourced from 2009 Ministry of Forestry data (1:250,000 scale). WRI reclassified the original land cover categories from the Ministry of Forestry dataset for use in the Suitability Mapper (2012), into the following categories: • Primary dry land forest, primary mangrove forest, primary swamp forest --> "primary forest" • Secondary dry land forest, secondary mangrove forest, secondary swamp forest --> "secondary forest" • Swamp, swamp scrubland --> "wetland" • Bare land, savannah, scrubland --> "grassland/shrub" • HTI, plantation --> "plantations" • Dry rice land, dry rice land mixed with scrub, rice land, fish pond --> "agriculture" • Mining, airport/harbor, settlement, transmigration area -->"settlements/other land use" • Bodies of water, cloud --> excluded • Exact definitions and descriptions of the methodologies used to produce this data are not available. Original data available at http://appgis.dephut.go.id/appgis/kml.aspx under "Penutupan Lahan 2009."	Ministry of Forestry Indonesia (2009). Land cover Indonesia 2006. Forestry Planning Agency of the Ministry of Forestry, 2009. Interpretation of 2005 and 2006 Landsat images. Provided and processed by Greenpeace. Prepared by the World Resources Institute (2012).
Peatlands	This layer shows the peatland in Kalimantan, classified by depth (1:250,000 scale). Depth categories (in cm): 0, <50, 50-100; 100-200; 200-400; 400-800; 800-1200. Dataset was digitized by Sekala (a local non-profit organization), atlas of peat land distribution Kalimantan (Wetlands International, 2004). Maps are available digitally online at <http://www.wetlands.or.id/publications_maps.php>. This dataset was prepared by the World Resources Institute for use in the Interactive Atlas of Indonesia's Forests (2009).	Wetlands International (2004). Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Prepared by the World Resources Institute (2012).
Conservation Area Buffers	Euclidean distance raster created from Kalimantan_conservation_areas shapefile which is subset of the Land classification map consisting of including Hutan Lindung (Protection Forest) and Hutan Konservasi (Conservation Forest). Raster values represent distance in meters to the nearest conservation area. Zero values fall within conservation areas. Used in Suitability Mapper (2012).	World Resources Institute (2012). Legal classification: Ministry of Forestry Indonesia (year unknown). Kawasan Hutan (Forest Estate) land use maps, General Direktorat of Planning, Ministry of Forestry. Downloaded from http://appgis.dephut.go.id/appgis/kml.aspx in March 2010, with maps for Riau and Central Kalimantan downloaded in March 2011. Processed and provided by Greenpeace. Prepared by the World Resources Institute (2012).

Water Resource Buffers	This is a Euclidean distance raster dataset derived from the combination of the following river and lake datasets in Kalimantan for WRI's Suitability Mapper (2012). Each raster value indicates the distance, in meters, to the closest river or lake. Lakes: GLWD-1 and GLWD-2, prepared for use in the Interactive Forestry Atlas of Indonesia (2009), displays the largest lakes and reservoirs of Indonesia. This dataset is a subset of the global product called the Level 1 Global Lakes and Wetlands Database (GLWD), produced by the World Wildlife Fund (WWF). It comprises the shoreline polygons of the largest lakes (area >= 50 square km) and reservoirs (storage capacity >= 0.5 cubic km) worldwide, including extensive attribute data. Rivers: This data displays the rivers of South East Asia, originally produced by Bakosurtanal, the Indonesian National Coordinating Agency for Surveys and Mapping. It was prepared by WRI for use in the Interactive Atlas of Indonesia's Forests (2009)	World Resources Institute (2012). Lakes: Bernhard Lehner and Petra Doell. World Wildlife Fund US, Washington DC, USA. Center for Environmental Systems Research, University of Kassel, Germany. The original GLWD database may be accessed online at http://www.worldwildlife.org/science/data/item1877.html. Rivers: Barkosurtanal, http://www.bakosurtanal.go.id Bakosurtanal, the Indonesian National Coordinating Agency for Surveys and Mapping. Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute.
Elevation	This layer shows the elevation (in meters) for Kalimantan. 90 meter resolution. Data was prepared by the World Resources Institute for use in the Suitability Mapper (2012).	Shuttle Radar Topography Mission (2008). Original data available at http://www2.jpl.nasa.gov/srtm/cbanddataproducts.html. Prepared by the World Resources Institute (2012).
Slope	This layer shows the slope (in percent) of Kalimantan calculated from the elevation layer (90 meter resolution): ArcToolBox, Spatial Analyst Tools, Surface, Slope (Output measurement: percent_rise).Data was prepared by the World Resources Institute for use in the Suitability Mapper (2012)	Shuttle Radar Topography Mission (2008). Original data available at http://www2.jpl.nasa.gov/srtm/cbanddataproducts.html. Prepared by the World Resources Institute (2012).
Rainfall	This layer shows the mean rainfall (in mm) for the period from 1989 to 2009 (1000 m resolution). Data was prepared by the World Resources Institute for use in the Suitability Mapper (2012)	WorldClim Global Climate data (1989–2009). Data available at <http://www.worldclim.org/>. Prepared by the World Resources Institute (2012).
Soil Drainage	This layer shows the soil drainage, based on result of a classification established from Kalimantan RePPProT dataon 'SL_drain1' field (1990, 1:250,000 scale) . This data was provided and processed by Daemeter Consulting and was prepared by the World Resources Institute for use in the Suitability Mapper (2012). Data separated into categories: stagnant; very poor; poor; moderately good; good; excessive; very excessive.	Regional Physical Planning Program for Transmigration (RePPProT) (1990). Data provided and processed by Daemeter Consulting. Prepared by the World Resources Institute (2012).
Soil Depth	This layer shows soil depth, bsaed on the result of a classification established from Kalimantan RePPProT data on 'Depthmnr1' field (1990, 1:250,000 scale). This data was provided and processed by Daemeter Consulting and was prepared by the World Resources Institute for use in the Suitability Mapper (2012). Data separated into categories: very shallow (0-10 cm); moderately shallow (26-50 cm); moderately deep (51-75 cm); deep (76-100 cm); very deep (101-150 cm); extremely deep (>150 cm)	Regional Physical Planning Program for Transmigration (RePPProT) (1990). Data provided and processed by Daemeter Consulting. Prepared by the World Resources Institute (2012).
Soil Acidity	This layer shows soil acidity, based on Kalimantan RePPProT data (1990, 1:250,000 scale). This data was provided and processed by Daemeter Consulting and was prepared by the World Resources Institute for use in the Suitability Mapper (2012). Data separated into categories of acidity: excessively acid (<4.0); extremely acid (4.0-4.5); very strongly acid (4.6-5.0); strongly acid (5.1-5.5); moderately acid (5.6-6.0); slightly acid (6.1-6.5); neutral (6.6-7.3)	Regional Physical Planning Program for Transmigration (RePPProT) (1990). Data provided and processed by Daemeter Consulting. Prepared by the World Resources Institute (2012).
Soil Type	This layer shows soil type, based on the result of a classification established from Kalimantan RePPProT data on 'SL_ORDER' field (1990, 1:250,000 scale) . This data was provided and processed by Daemeter Consulting. Soil categories from RePPProT were then re-classified by the World Resources Institute according to the FAO Digital Soil Map of the World, for use in the Suitability Mapper (2012). The FAO data is available at <http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116> . Data separated into categories: Inceptisol; Oxisol; Alfisol; Ultisol; Spodosol; Entisol; Histosol.	Regional Physical Planning Program for Transmigration (RePPProT) (1990). Data provided and processed by Daemeter Consulting. Prepared by the World Resources Institute (2012).
Legal Classification	This layer shows legal classification, based on Ministry of Forestry categories (1:250,000 scale): • convertible production forest (HPK) • limited production forest (HPT) • non forestland (APL) • production forest (HP) • protection forest (HL) • conservation forest (KSA-KPA)	Ministry of Forestry Indonesia (year unknown). Kawasan Hutan (Forest Estate) land use maps, General Direktorat of Planning, Ministry of Forestry. Downloaded from http://appgis.dephut.go.id/appgis/kml.aspx in March 2010, with maps for Riau and Central Kalimantan downloaded in March 2011. Processed and provided by Greenpeace. Prepared by the World Resources Institute (2012).

Logging Concessions (HPH)	This layer shows logging concessions with data from the Ministry of Forestry.	Ministry of Forestry Indonesia (year unknown). IUPHHK_HA (logging concessions), provided by the Planning Department of the Ministry of Forestry, Indonesia (Direktorat Jenderal Planologi Kehutanan, Kementerian Kehutanan Republik Indonesia). Google Earth Format Downloaded from: http://appgis.dephut.go.id/appgis/kml.aspx July 30 2010. Provided and processed by Greenpeace. Prepared by the World Resources Institute (2012).
Timber Concessions (HTI)	This layer shows timber concessions with data from the Ministry of Forestry.	Ministry of Forestry Indonesia (year unknown). IUPHHK_HT (timber plantation concessions), provided by the Planning Department of the Ministry of Forestry, Indonesia (Direktorat Jenderal Planologi Kehutanan Kementerian Kehutanan Republik Indonesia). Google Earth Format Downloaded from: http://appgis.dephut.go.id/appgis/kml.aspx downloaded September 2010. Updated using 1) MoFor (2010) Pemanfaatan Hutan, Data dan Informasi, Tahun 2010, Ministry of Forestry Indonesia, November 2010 www.dephut.go.id/files/Buku pemanfaatan 2010.pdf and 2) MoF (2011), online WebGis Kehutanan, online interactive map http://webgis.dephut.go.id/ditplanjs/index.html accessed May 12 2011. Processed and provided by Greenpeace. Prepared by the World Resources Institute (2012).
Oil Palm Concessions	This layer shows oil palm concessions with data from the Ministry of Forestry.	Ministry of Forestry Indonesia (year unknown). Perkebunan (Agriculture plantations). Direktorat Jenderal Planologi Kehutanan, Kementerian Kehutanan Republik Indonesia, downloaded as Google Earth files (kml) from http://appgis.dephut.go.id/appgis/kml.aspx accessed 29 July 2010, supplemented with data gathered from provincial planning agencies (BPN). Processed and provideed by Greenpeace (2011). Prepared by the World Resources Institute (2012).
Tree Cover Change 2001-2010	Tree cover loss to <30% canopy cover for each year 2000-2010. 60 m resolution, using combination of Landsat and MODIS satellite imagery. Each year starts in November – so "2006" is November 2005- October 2006. All change that took place on forest classified as "Intact Forest 2000" was designated as primary forest cover loss.	Hansen, M. (2012). University of Maryland. Prepared by the World Resources Institute (2012).
Political Boundaries	This dataset, prepared for use in the Interactive Atlas of Indonesia's Forests (2009), displays the provinces and districts Kalimantan. It was generated by WRI using the provinces dataset produced by Badan Pusat Statistik (BPS) in 2003.	Badan Pusat Statistik (BPS-Statistics Indonesia). Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Prepared by the World Resources Institute (2012).
Rivers	The downloadable dataset is a combination of rivers and lakes prepared by WRI. Rivers: This data displays the rivers of South East Asia, originally produced by Bakosurtanal, the Indonesian National Coordinating Agency for Surveys and Mapping. It was prepared by WRI for use in the Interactive Atlas of Indonesia's Forests (2009) Lakes: GLWD-1 and GLWD-2, prepared for use in the Interactive Forestry Atlas of Indonesia (2009), displays the largest lakes and reservoirs of Indonesia. This dataset is a subset of the global product called the Level 1 Global Lakes and Wetlands Database (GLWD), produced by the World Wildlife Fund (WWF). It comprises the shoreline polygons of the largest lakes (area >= 50 square km) and reservoirs (storage capacity >= 0.5 cubic km) worldwide, including extensive attribute data.	Prepared by World Resources Institute (2012). Rivers: Barkosurtanal, http://www.bakosurtanal.go.id Bakosurtanal, the Indonesian National Coordinating Agency for Surveys and Mapping. Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Lakes: Bernhard Lehner and Petra Doell. World Wildlife Fund US, Washington DC, USA. Center for Environmental Systems Research, University of Kassel, Germany. The original GLWD database may be accessed online at http://www.worldwildlife.org/science/data/item1877.html.
Roads	This dataset displays detailed roads for Indonesia. It comes from the basemaps of Indonesia, developed by Bakosurtanal. The time period corresponds to the 2003 situation of roads including logging roads. This dataset was prepared by the World Resources Institute for use in the Interactive Atlas of Indonesia's Forests (2009).	Bakosurtanal, the Indonesian National Coordinating Agency for Surveys and Mapping. Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Prepared by the World Resources Institute (2012).

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Settlements	This dataset displays the main cities of Kalimantan. It is a subset of the Gridded Population of the World (GPW), Global Rural-Urban Mapping Project (GRUMP), Aplha version 1: settlement points. This data also provides with population counts of the settlement points for 2000, 1995, 1990. The World Resources Institute prepared this dataset for use in the Interactive Atlas of hte Indonesia's Forests (2009). The original GRUMP data was produced by the Socioeconomic Applications and Data Center (SEDAC) of Center for International Earth Science Information Network (CIESIN) at Columbia University. The original data are available from the SEDAC website, <http://sedac.ciesin.columbia.edu/gpw> .	Center for International Earth Science Information Network (CIESIN) at Columbia University. Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Prepared by the World Resources Institute (2012).
Population Density	This data displays the population density per square kilometer. It is a subset (for Indonesia) of the Gridded Population of the World, version 3 (GPWv3). This dataset was prepared by the World Resources Institute for use in the Interactive Atlas of Indonesia's Forests (2009). The original dataset is available from CIESIN here, <http://sedac.ciesin.columbia.edu/gpw/>. Gridded Population of the World, Version 3 (GPWv3) consists of estimates of human population for the years 1990, 1995, and 2000 by 2.5 arc-minute grid cells and associated datasets dated circa 2000. The data products include population count grids (raw counts), population density grids (per square km), land area grids (actual area net of ice and water), mean administrative unit area grids, centroids, a national identifier grid, national boundaries, and coastlines. These products vary in GIS-compatible data formats and geographic extents (global, continent [Antarctica not included], and country levels). A proportional allocation gridding algorithm, utilizing more than 300,000 national and sub-national administrative units, is used to assign population values to grid cells. GPWv3 is produced by the Columbia University Center for International Earth Science Information Network (CIESIN) in collaboration with Centro Internacional de Agricultura Tropical (CIAT).	Center for International Earth Science Information Network (CIESIN) at Columbia University, in collaboration with Centro Internacional de Agricultura Tropical (CIAT). Data available in Minnemeyer et al. (2009). Interactive Atlas of Indonesia's Forests CD-ROM. Washington, DC: World Resources Institute. Prepared by the World Resources Institute (2012).

Acknowledgements

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End Notes

[i] http://wri.org/project/potico/contact

[ii] These default environmental and crop criteria settings are based on the methodology developed by WRI and Sekala, detailed in Gingold et
- Land Cover - Suitable: grassland/shrub; plantations; agriculture; settlements/other uses. Not suitable: primary forest; secondary forest, wetland
- Peat Depth – Suitable:0 cm. Not suitable: any value > 0 cm
- Slope – Suitable: 0-30%. Not suitable : >30%
- Conservation Area Buffer – Suitable: >1000 m. Not suitable: <1000m
- Water Resource Buffer – Suitable: > 100 m. Not suitable: <100 m
- Elevation – Suitable: 0-1000m. Not suitable: >1000 m
- Rainfall – Suitable: 1250-6000mm/yr. Not suitable: >6000mm/yr; <1250mm/yr
- Soil Drainage – Suitable: good; moderately good; excessive; poor. Not suitable: very excessive; very poor; stagnant
- Soil Depth – Suitable: moderately deep (51-75 cm); deep (76-100 cm); very deep (101-150 cm); extremely deep (>150 cm). Not suitable: very shallow (0-10 cm); moderately shallow (26-50 cm)
- Soil Acidity (pH) – Suitable: excessively acid (<4.0); extremely acid (4.0-4.5); very strongly acid (4.6-5.0); strongly acid (5.1-5.5); moderately acid (5.6-6.0); slightly acid (6.1-6.5); neutral (6.6-7.3). Not suitable: none.
- Soil Type – Suitable: Inceptisol; Oxisol; Alfisol; Ultisol; Spodosol; Entisol. Not suitable: Histosol

[iii]The World Resources Institute reclassified the original land cover categories from the Ministry of Forestry dataset for use in the Suitability Mapper into the following categories:
- Primary dry land forest, primary mangrove forest, primary swamp forest --> "primary forest"
- Secondary dry land forest, secondary mangrove forest, secondary swamp forest --> "secondary forest"
- Swamp, swamp scrubland --> "wetland"
- Bare land, savannah, scrubland --> "grassland/shrub"
- HTI, plantation --> "plantations"
- Dry rice land, dry rice land mixed with scrub, rice land, fish pond --> "agriculture"
- Mining, airport/harbor, settlement, transmigration area -->"settlements/other land use"
- Bodies of water, cloud --> excluded

[iv] Calculated from the elevation layer: ArcToolBox, Spatial Analyst Tools, Surface, Slope (Output measurement: percent_rise).

[v] Based on result of a classification established from Kalimantan RePPProT data on 'SL_drain1' field (1990)

[vi] Based on the result of a classification established from Kalimantan RePPProT data on 'Depthmnr1' field (1990)

[vii] Based on the result of a classification established from Kalimantan RePPProT data on 'SL_ORDER' field (1990). Soil categories from RePPProT were then re-classified according to the FAO Digital Soil Map of the World, for use in the Suitability Mapper (2012). The FAO data is available at <http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116> .

[viii] Data used is a subset (for Indonesia) of the Gridded Population of the World, version 3 (GPWv3). The original dataset is available from CIESIN here, <http://sedac.ciesin.columbia.edu/gpw/>. Gridded Population of the World, Version 3 (GPWv3) consists of estimates of human population for the years 1990, 1995, and 2000 by 2.5 arc-minute grid cells and associated datasets dated circa 2000. The data products

include population count grids (raw counts), population density grids (per square km), land area grids (actual area net of ice and water), mean administrative unit area grids, centroids, a national identifier grid, national boundaries, and coastlines. These products vary in GIS-compatible data formats and geographic extents (global, continent [Antarctica not included], and country levels). A proportional allocation gridding algorithm, utilizing more than 300,000 national and sub-national administrative units, is used to assign population values to grid cells.

[ix] Developed using combination of Landsat and MODIS satellite imagery. Each year starts in November – so "2006" is November 2005-October 2006.

[x] Disclaimer: Use and/or reliance on any data and/or information included on the Suitability Mapper website is at the user's own risk. The World Resources Institute and the supporters of Project POTICO make no claim, representation, or warranty as to the accuracy of the data and information included on the Suitability Mapper website. The World Resources Institute and supporters of Project POTICO disclaim any responsibility associated with use of and/or reliance on any of the data and/or information included on the Suitability Mapper website and will not have any liability of any kind relating to such use and/or reliance.

[xi]To simplify the analysis, only the land area is considered. Water bodies are excluded from the analysis.

[xii] Suitability maps were developed based on a GIS approach, using ArcGIS's Model Builder. Overlay operations were applied based on the weighted values of each variable within each thematic layer map (carbon and biodiversity, soil and water protection, suitability for oil palm cultivation). A weighted overlay was used to combine the layer maps, generating an individual value for each pixel and producing a new map based on the combined factors. The weighted values used in the overlay operations were only performed on raster maps.

[xiii] HCV 1 refers to "Areas with Important Levels of Biodiversity;" HCV 2to "Natural Landscapes & Dynamics;"HCV 3 to "Rare or Endangered Ecosystems" (Toolkit for Identification of High Conservation Values in Indonesia, 2008)

[xiv] Roundtable on Sustainable Palm Oil (RSPO), ISRIC World Soil Information, Regional Physical Planning Programme for Transmigration (RePPProT), and SarVision.

[xv] The method referred to the following technical documents cited in the Annex 1 of the National Interpretation of RSPO Principles and Criteria for Sustainable Palm Oil Production Republic of Indonesia (2008): Petunjuk Teknis Budidaya Kelapa Sawit. Direktorat Jenderal Perkebunan. Departemen Pertanian. Jakarta, 1997. and Pedoman Teknis Pembangunan Kebun kelapa Sawit Direktorat Jenderal Perkebunan. Departemen Pertanian. Jakarta. (Akan dirilis tahun 2007). See <http://www.scribd.com/doc/31011709/5/Persyaratan-Tumbuh> and <http://www.scribd.com/dymaz_ardhita/d/61502477-kelapa-sawit>.

[xvi] Mantel, S., H. Wosten, and J. Verhagen. 2007. "Biophysical Land Suitability for Oil Palm in Kalimantan, Indonesia." Report 2007/01, ISRIC – World Soil Information, Alterra, Plant Research International,Wageningen UR, Wageningen.

[xvii] Land Resources Department/Bina Program. 1990. "The Land Resources of Indonesia: A National Overview." Jakarta, Indonesia. Regional Physical Planning Program for Transmigration (RePPProT), Land Resources Department, Natural Resources Direktorat Bina Program, Direktorat Jenderal Penyiapan Pemukiman, Departmen Transmigrasi.

[xviii] Wielaard, N. 2005. "Mapping potential areas for sustainable plantation development: A flexible planning tool." SarVision. Proceedings from 3rd Round Table on Sustainable Palm Oil, 2005.