Land Use and Land Cover Baseline Report

Data and analysis of land use and land cover practices, South Department, Haiti

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Abstract

This report provides initial key results of the findings of land use and land cover mapping in the South Department of Haiti. The initial analysis focused on three geographic levels: the entire South Department, nine communes of the southwest coast, and the watershed of Port-à-Piment. Further data analysis is possible at the commune or watershed level for other actors or purposes.

The objective this report is to provide a baseline measurement of land cover and land use conditions in the region based on satellite imagery taken in November 2011. With millions of dollars of investment in ecosystem management from communities, non-governmental organizations and government ministries, this non-project specific monitoring tool allows for measurement of current land use in the department. This data serves as a baseline against which to compare future observed changes, if the mapping is repeated in five to ten years as recommended by research teams. It also serves as critical data to help with future regional-scale long-term land use planning efforts. Land use and land cover mapping at regional scale is a critical component needed to run a variety of models for land use optimization, regional production potential under different cropping patterns, and identify high-priority development and conservation zones. Land management tools that center on positive land-use planning can be highly effective means for this type of planning.

The LULC analysis confirms earlier hypotheses regarding the predominance of agriculture in the South Department. The analysis identifies 71% of the South Department's land as being used for some form of agricultural cultivation (Agroforestry, Agroforestry Shrub, Cropland and Pasture). The initial analysis shows that reversing the trend of forest cover loss will be a key target for the region, as only 3% of the land area has forest cover and the government seeks to increase sustainable land management on areas with slopes greater than 15%.

Résumé

Ce rapport fourni les résultats et conclusions principales sur la cartographie de l'utilisation et couverture du sol dans le département du Sud en Haïti. L'analyse préliminaire se concentré sur trois niveaux géographique: le département du Sud, neuf communes de la côte sud, et le bassin versant de Port-à-Piment. Il y a aussi le possibilité de fournir plus des ensembles des données au niveau de bassin versant ou commune pour analyse par d'autres organismes.

Le but de ce rapport c'est de fournir une mesure de base sur les conditions d'utilisation et couverture de sol, basé sur l'imagerie satellite de novembre 2011. Avec des millions de dollars d'investissement dans l'aménagement des écosystèmes de communautés, les organisations non-gouvernementales, et les ministères, cet outil de surveillance, pas associé avec un projet spécifique, permettre le mesurèrent de l'utilisation actuel de sol dans le département. Ces données sont une base pour mesurer les changements de l'avenir, si la cartographie est refaite dans cinq ou dix ans, avec les recommandations des équipes de recherche. C'est aussi des données critiques pour des efforts de planification d'utilisation de sol au niveau régionale et de long terme. La cartographie sur l'utilisation et couverture de sol au niveau régionale est un component critique pour exécuter des modèles statistiques pour l'optimisation de utilisation de terre, la production potentielle régionale sur les modèles de culture, et d'identifier les zones de haute priorité pour le développement et la conservation. Outils pour l'aménagement de terrain qui sont basés sur la planification positive de terrain peut être très efficace pour ce type de planification.

Cet LULC analyse confirme des hypothèses passées regardant la prédominance d'agriculture dans le département du Sud. Cette analyse identifiée 71% du terrain de département utilisé pour l'agriculture (l'agroforesterie, l'agroforesterie-shrub, terres agricoles et pâturage). L'analyse préliminaire démontre que la tendance de la perdu de surface boisée doit être une cible clé pour la région, comme il reste que 3% de la surface boisée et le gouvernement veut l'aménagement durable du terrain sur les pentes de plus de 15%.

Acknowledgements

The Earth Institute team would like to acknowledge the individual and organizations that made this work possible:

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Acronyms

CNIGS	National Center for Geo-Spatial Information
CORINE	Coordination of Information on the Environment
CRS	Catholic Relief Services
CSI	Côte Sud Initiative
EI	The Earth Institute
GIS	Geographic Information Systems
LDSF	Land Degradation Surveillance Framework
LULC	Land Use/ Land Cover
MARNDR	Ministry of Agriculture, Natural Resources, and Rural Development
ORE	Organization for the Rehabilitation of the Environment
UNEP	United Nations Environment Programme
UNOPS	United Nations Office for Project Services

Executive summary

This land use and land cover (LULC) report summarizes the methodology and outputs from the baseline mapping of the South Department in Haiti from satellite imagery taken in November 2011. The results are meant to serve three intended purposes:

- To provide a measurement of land cover and land use conditions as of November 2011, to be used as a baseline indicator for forest cover and land use classes. With millions of dollars of investment in ecosystem management from communities, non-governmental organizations and government ministries, this non-project specific monitoring tool allows for measurement of current land use in the department. This data serves as a baseline against which to demonstrate change in future comparisons.

- To provide high-resolution imagery to regional government agencies, technical institutes, universities and communities for enhanced land use management planning. The high-resolution imagery can provide maps at the commune, watershed or regional level; these maps should be integrated into local land use planning processes. They can be used to inform the extension agents from the Ministry of Agriculture, Natural Resources and Rural Development (MARNDR) and support local community based organizations that take active role in reforestation, agriculture and land management programs. It is recommended that extension agents be trained in the interpretation and importance of land use and land cover maps, including training on how to explain maps and concepts to community groups for participatory planning purposes.

- To provide critical data to help with future regional-scale long-term land use planning efforts. Land use and land cover mapping at regional scale is a critical component needed to run a variety of models for land use optimization, regional production potential under different cropping patterns, and identify high-priority development and conservation zones. Land management tools that center on positive land-use planning can be highly effective.

This report provides initial key results of the findings, with analysis broken into three areas of interest to the research team: the South Department (excepting Ile à Vache), nine communes of the southwest coast, and the watershed of Port-à-Piment. There is a possibility for future analysis broken down into other commune or watershed levels as needed for other actors or purposes.

This study was designed to be used by local GIS experts to provide maps to communities. The Earth Institute provided three training seminars and provided day-to-day support of the GIS analyst employed by the Cote Sud Initiative and direct support to ORE and CRS who were research and project partners.

Additional analysis related to the study areas of the nine southwest coast communes, as well as the Port-à-Piment watershed, are available in the forms of integrated baseline analyses prepared by the Earth Institute at Columbia University.

Study Area

The study area covers the South Department of Haiti; Ile-à-Vache was outside the satellite imagery, and was not included in the analysis. The total area studied covers a total of 2645 km^2. The study area includes the communes of the southwest coast from Tiburon to the south-central coastal communes to Aquin. The area includes the Pic Macaya, as well as the southern half of the Pic Macaya National Park. Included in the region are also the plains of Les Cayes and Torbeck, which are zones of high agricultural productions and that serve as important breadbaskets for the region and country.
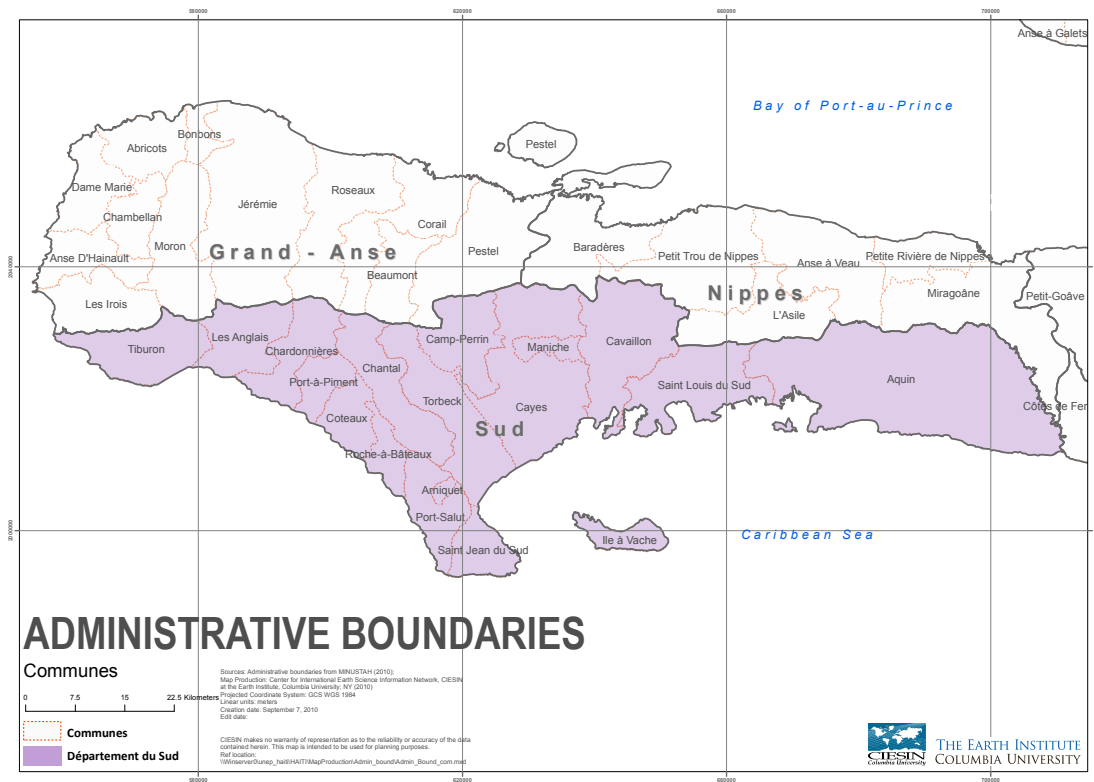
Map 1: Administrative boundaries, South Department. All of the Department, excepting Ile-à-Vache, are included in the LULC mapping.

Key Findings

Reversing the trend of forest cover loss will be a key target for the region, as only 3% of the land area has forest cover. The target will be to increase productive and sustainable forms of land use on slopes greater than 15%. These include primarily forest cover, agro-forestry, woodlots, or open woodland. This transition to forest cover on steep slope, instead of the steep slope agriculture which is the predominant land cover in the region as of 2012, would help to ensure environmental security and reduce the risks associated with flooding and severe erosion.

South Department

The LULC analysis confirms earlier hypotheses regarding the predominance of agriculture in the South Department. The analysis identifies 71% of the South Department's land as being used for some form of agricultural cultivation (Agroforestry, Agroforestry Shrub, Cropland and Pasture). This is an important figure that can be used to estimate current production levels in the region, based on crop monitoring and current yield rates. For future modeling, in conjunction with current and potential yield rates, it may be possible to estimate potential targets and levels of optimized production.

Summary of LULC for the South Department		
Class	Area (km2)	Area(%)
Agroforestry	611	24%
Agroforestry-Shrub	322	13%
Barren Land	195	8%
Bushland	97	4%
Cropland	354	14%
Forest	63	3%
Open Woodland	86	3%
Pasture	501	20%
Rock	37	1%
Shrubland	128	5%
Urban	73	3%
Woodlot	45	2%
Water bodies	15	1%

The LULC analysis shows that across the Department, on steep slopes (categorized as slopes greater than 30%), 45% of land is being used for agro-forestry. In contrast, only 10% of these steep areas are covered in forests. On steep slopes, 26% of the analyzed area is being used for agricultural cultivation.

Forest represents only 3% of the total area, totaling only 63 km2 of surface area. Of the forested area, 40% of is located in the nine communes along the southwest coast that have been further analyzed in the 2012 Integrated Baseline Survey. As this is the zone that contains the critical conservation area surrounding the Port-à-Piment watershed and the Pic Macaya National Park, these findings reinforce the priority to concentrate efforts on conservation and protection to the forest reserves along the communes of the southwest coast.

Nine Communes of the Southwest Coast

Within the nine communes stretching from Saint Jean du Sud to Tiburon, the proportion of agroforestry is higher than 34%. Based on empirical observations, agroforestry is usually linked to heterogeneous land use types and uncoordinated land management[1]. All forested areas are

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[1] This classification can represent planning at the farmer plot level but not between farmers.

in the upper elevations of the zone. Almost half of the land within the agro-pastoral agro-ecological zone is used for agro-forestry, while only 17% is used for pasture and 11% is used as cropland.
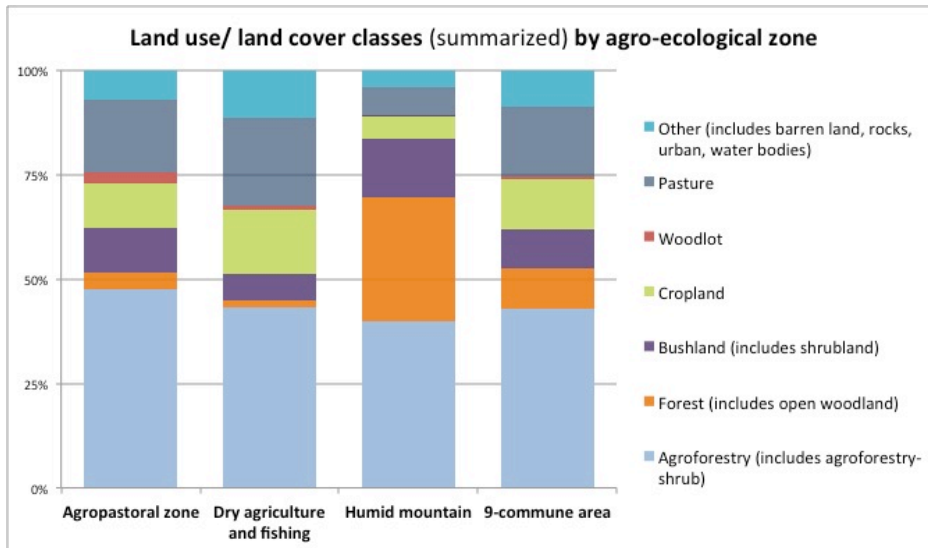

Figure 1 Land use and land cover summarized by agro-ecological zone.

Port-à-Piment Watershed

Only 4% of the Port-à-Piment watershed, whose upper boundaries reach the Pic Macaya National Park, is classified as forest cover. Formal crop cultivation (cropland) is lower than observed in the rest of the region at only 8%.

Methodology

The following section describes the land use mapping methodology. The objective is to identify the process and protocol so that future analysts can repeat this methodology in five or ten years for the comparative study. Training on this methodology was conducted by Columbia University over several workshops in the South Department, with partner representatives of MARNDR, ORE and CRS as attendees. The processing and analysis of the LULC mapping was conducted at Columbia University.

Land use/land cover classes

The land cover classes are based on the Coordination of Information on the Environment program of the European Commission (CORINE) land cover classification (CORINE 1994). This is the same classification used by CNIGS at the national scale; it is also the same as the 2011 Land Degradation Surveillance Framework (LDSF) study conducted in the Port-à-Piment watershed. The rationale for this classification system is to maintain classes that are compatible with other national classification, but allow for incorporation of local specificities. Below is a table that describes the categories used for the decision tree and provides details on the terms for classification. The decision tree was adapted to match the LULC forms. Classes are defined using a decision tree (see next page).

Table 1: LULC classification scheme

Class name	Morphology	Vegetation structure	Primary use	Tree cover	Herbaceous cover	Rock cover
Agroforestry	Cultivated or managed	N/A	Food/beverage	>10%		
Agroforestry-Shrub	Cultivated or managed	N/A	Food/beverage	>30%		
Barren Land	N/A	N/A	No food and beverage	<10%	<10%	≤70%
Bushland	Other	Tree and shrubs		40-60%		
Cropland	Cultivated or managed	N/A	Food/beverage	<10%		
Forest	Other	Tree		>60%		
Open Woodland	Other	Tree		10-40%		
Pasture	N/A	N/A		<10%	>10%	
Rock	N/A	N/A	No food and beverage	<10%	<10%	≥70%
Shrubland	Other	Trees		10-40%		
Urban	Artificial	N/A				
Woodlot	Cultivated or managed	N/A	Timber or Fuelwood	>10%		
Water bodies	Regularly flooded	Fresh water				

Surface
- Artifical → Urban
- Aquatic → Water body
- Cultivated or Managed
  - Yes → Agricultural
    - Food Beverage → Woody Cover
      - < 10% → Plot Flooded
        - Yes → Cropland
        - No → Flooded Cropland
      - ≥10% → Agroforestry
    - Timber Fuelwood → Woody Cover
      - ≥10% → Woodlot
  - Yes or No → Natural/Semi Natural
    - Food Beverage → No → Flooded
      - No → Trees
        - Yes → Woody Cover
          - 10–40% → Shrubs
            - Yes → Shrubland
            - No → Open Woodland
          - 40–60% → Shrubs
            - Yes → Bushland
            - No → Woodland
          - ≥60% → Forests
        - No → Shrubs → Yes → Woody Cover
          - 10–40% → Shrubland/Savannah
          - ≥40% → Thicket
        - Yes or No → Woody Cover
          - < 10% → Food Beverage = No → Herbaceous Cover
            - <10% → Rock Cover
              - <70% → Barren Land
              - ≥70% → Rock
            - ≥10% → Pasture
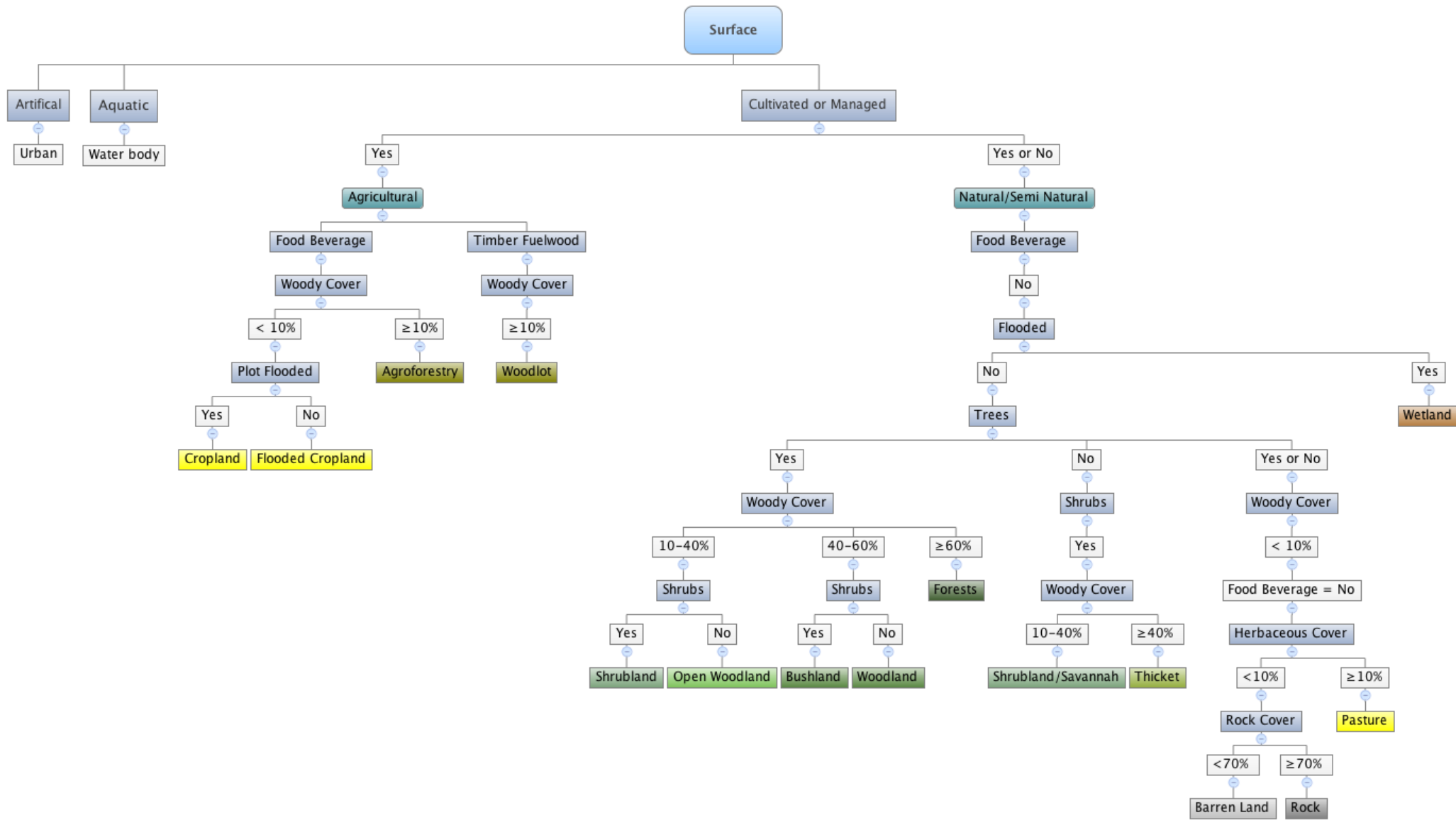   - Yes → Wetland

Figure 2: LULC classification scheme

Field sampling

Field data were collected using a stratified sampling based on information on the Department's agro-ecological zones, provided by ORE. This sampling strategy was chosen in consideration of time and cost effectiveness, as well as questions of available human resources. It is important to emphasize the limitations of such sampling design in term of bias and data representativeness.

Design

For the analysis, 500 plots were divided into approximately ten transects across the sampled areas of the South Department. Each plot comprised an area of 81 m^2 (9mx9m.) Data was collected using paper forms and geographic coordinates captured using a GPS. However, as a result of inaccuracies with the GPS systems in the field, both high resolution satellite imagery and a buffer zone of 729 m^2 with the same characteristics as the plot was always considered.
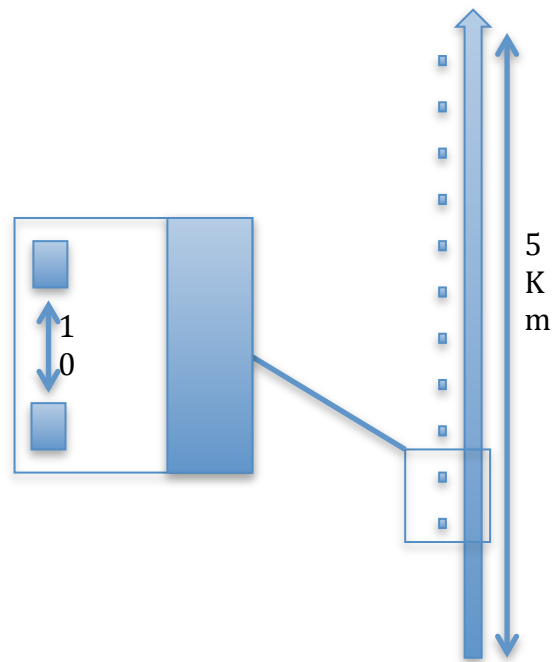
Figure 3: Sampling strategy for LULC plots
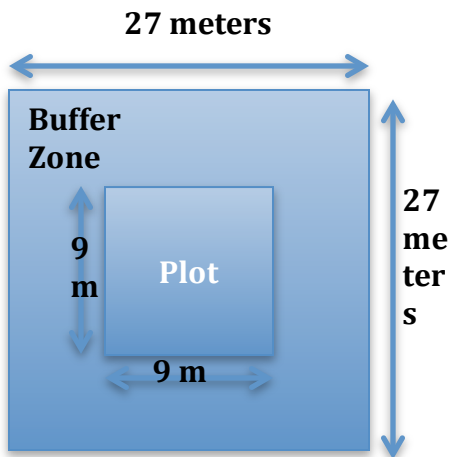
Figure 4: Buffer zones in plot data collection

Field procedures

Each team, composed of three people, measured the plots with the GPS units, logged the different land observations (i.e. morphology, vegetation structure), photographed the land use or land cover type and took GPS coordinates. After completing one plot, the research team would walk 100 meters along the transect for the next plot and then move leftward until finding an area with a homogenous land cover over 729 m^2. The team would repeat the steps above at each plot for a consistent collection of data.

Figure 5 The photos above show the process for ground truthing different transects to verify classification.

Data cleaning

Upon completion of the field data collection survey, the data were entered manually into a database and verified using logic checks and thresholds. A second verification was done by overlaying the satellite image and the database to make sure than observed data corresponded to satellite data.

Satellite images

The satellite images acquired are Worldview 2 images with the following characteristics:

- Multispectral 8 bands
- 2 meters resolution
- 6.5 meters accuracy (Orthoready product)

In comparison with standard high-resolution images such as Ikonos or Quickbird, Worldview has four additional spectral bands in its eight-band multispectral configuration. In comparison to the standard high resolution (blue, green, red, near infrared (NIR)), Worldview 2 has eight bands (coastal, blue, green, yellow, red, red edge, NIR1, NIR2).

Mapping method

The methodology is adapted from the methodologies developed by Chris Small and Sean Smukler on the Millennium Village Project Land Use Mapping. (Small 2002) This approach is derived from the SMA extraction protocol which sets a classification scheme using the Random Forest regression algorithm developed by Leo Breiman and Adel Cutler. (Liaw 2002,

Figure 6 Mapping methodology and process for the LULC mapping.

Challenges and limitations of the method

As this study is meant to be performed at future intervals to demonstrate change in land use and land cover over time, it is important to note the potential challenges and limitations of the method of data collection and inaccuracy employed in the creation of this report.

GPS inaccuracy

The field data collected are located with an accuracy of three to seven meters, whereas each pixel is located with and accuracy of approximately 6.5 meters, according to vendor specifications. Thus when overlaid, datasets may be displaced from one another by as much as thirteen meters. To counter this, each field plot is observed within a homogenous buffer zone of the same land cover type. Below is an example of two land covers with their boundary within the inaccuracy buffer. The plot, which describes one type of land cover, could be located anywhere within the red circle, reinforcing the necessity of maintaining the same type of land cover within 729 m^2.

Land cover class separation
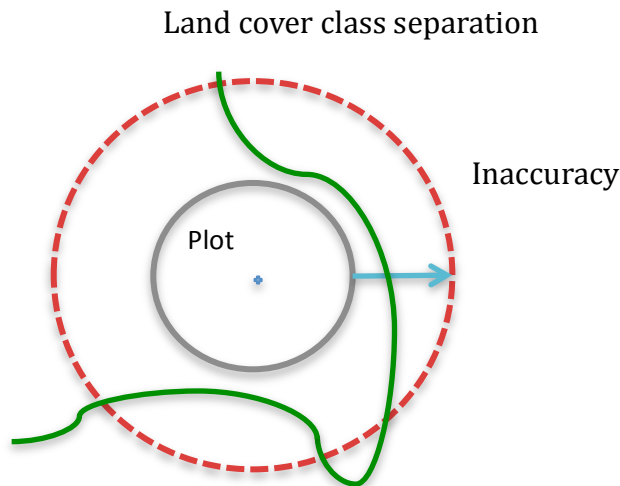
Inaccuracy

Plot

Figure 7: Inaccuracy buffer in field plot data collection

Ground truthing showed very heterogeneous terrain and mixed land use

The terrain mapped is very heterogeneous. Most of the land use has little organization and is distributed in a patchwork fashion. Cultivation occurs under tree coverage, making it very difficult to map using satellite images. The classification scheme therefore recognizes that the agro-forestry and savannah categories are often mixed use. The mapping considered the predominant features when assigning the classification.

Pace of land use change

The fieldwork and the image analysis were collected during the two months following the image acquisition window. The pace of land use change has not been recorded within this study, but based on empirical observation it is suspected that changes are often both seasonally and annually. The cropping patterns and harvest also influences the vegetative cover. Preliminary analysis, to be released in a later report, shows that monthly variation of vegetation is significant in specific classes of agriculture and savannah. The research team expects less observable changes in the forestry and agro-forestry classes. The change over the last decade is expected to show significant changes in land use areas but has not been determined at the point of this study.

Results

Reversing the trend of forest cover loss will be a key target for the region, as only 3% of the land area has dense forest cover. The target will be to increase productive and sustainable forms of land use on slopes greater than 15%. These include primarily forest cover, agro-forestry, woodlots, or open woodland. This transition to forest cover on steep slope, instead of steep slope agriculture which prevails in the region as of 2012, would help to ensure environmental security and reduce the risks associated with flooding and severe erosion.

South Department

USAID has identified four main agro-ecological zones in the South Department: 1) humid mountain agricultural zone; 2) agro-pastoral zone 3) dry-agriculture and fishing zone and 4) plains under monoculture zone (FEWS NET, USAID et al 2005). The agro-ecological zones summarize both the type of livelihood that prevails within that region and the biophysical parameters of the corresponding area.
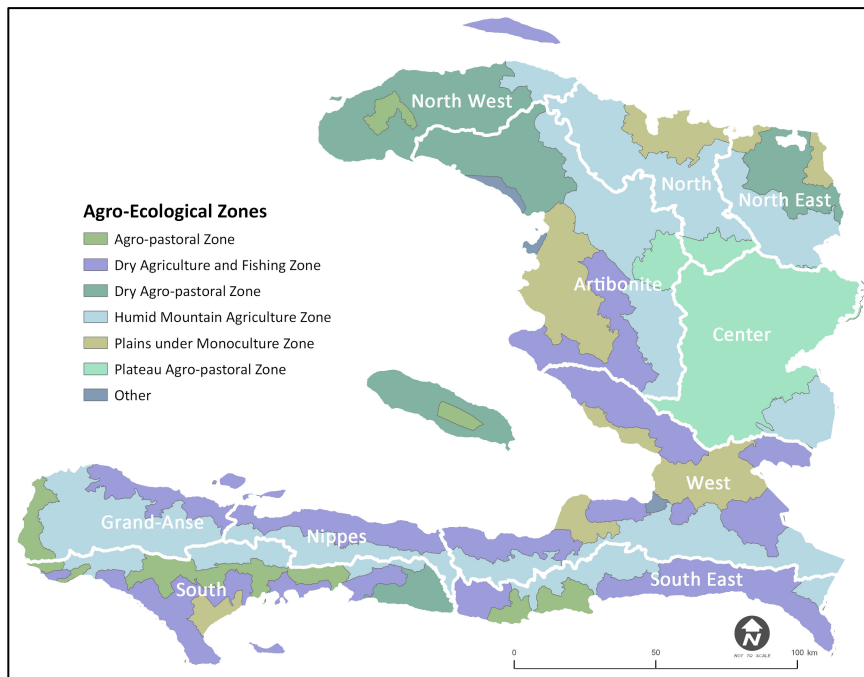
Map 2 Agro-Ecological zones. Source USAID, 2008

The LULC results are mapped at the departmental level in the map below. In alignment with expectations, the department-level map confirms that the majority of forest cover (>60% coverage with trees) is located around the Pic Macaya National Park in the western portion of the Department.   This data is intended to demonstrate changes over time and a static description of 2011 land uses. This also is a tool for local planners and community level land use plans.

Legend

- Agroforestry
- Agroforestry-shrub
- Barren land
- Bushland
- Cropland
- Forest
- Open woodland
- Pasture
- Rock
- Shrubland
- Urban
- Woodlot
- Water bodies

0 5 10   20   30
Km
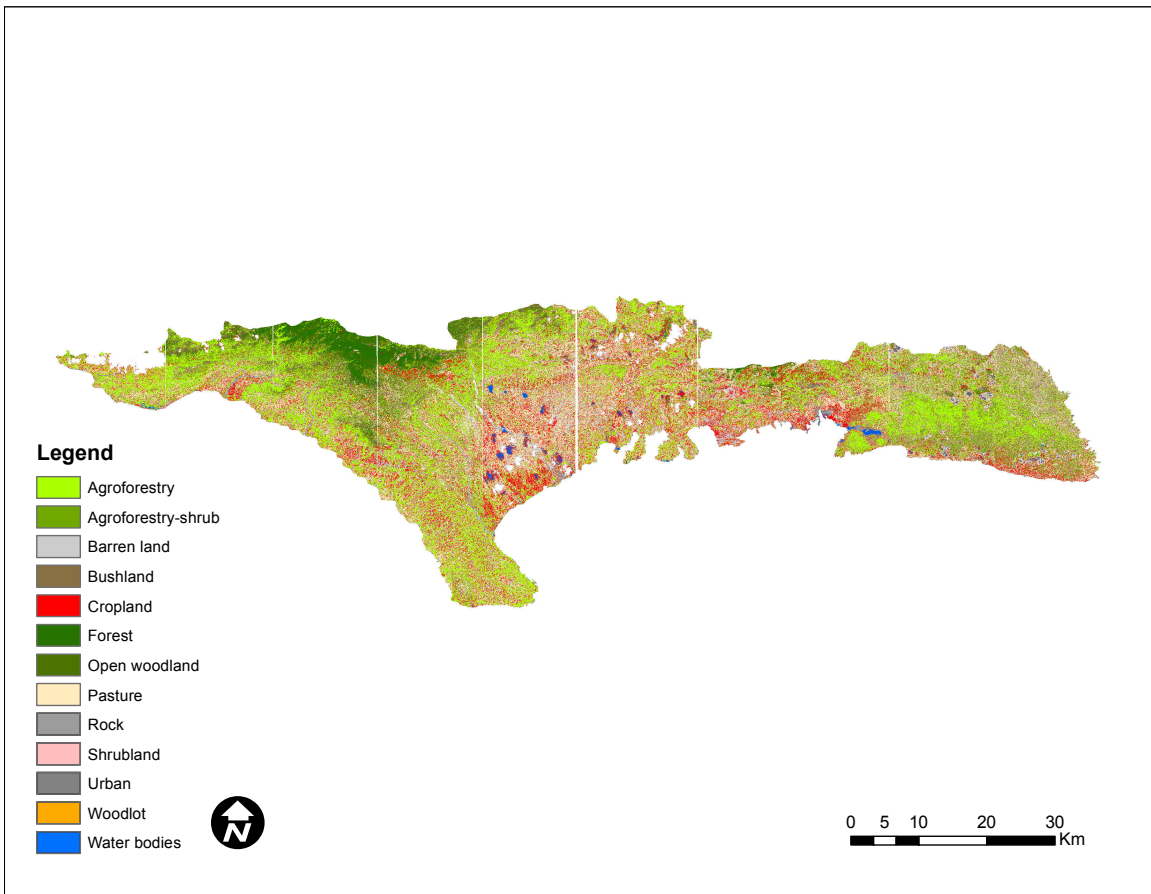
Map 3 South Department land use and land cover map.

The table below summarizes the total land area covered by each class across the department and the corresponding percentage of the total. The dominant class is agroforestry at 24%, followed by pasture at 20% and cropland at 14%. Forest only represents 3% of the South Department, while woodlots represent only 2% of the total area coverage.

Table 2: LULC class designation, South Department

Class	Area (km2)	Area (%)
Agroforestry	611	24%
Agroforestry-Shrub	322	13%
Barren Land	195	8%
Bushland	97	4%
Cropland	354	14%
Forest	63	3%
Open Woodland	86	3%
Pasture	501	20%
Rock	37	1%
Shrubland	128	5%
Urban	73	3%
Woodlot	45	2%
Water bodies	15	1%

Table 3: LULC analysis by slope and elevation, South Department

Land Use, Land Cover Class	Area (km^2) above 30% slope	Percent of area with >30% slope by LULC class above	Area (km^2) above 350m in elevation	Percent of area above 350m by LULC class
Agro-Forestry (includes agro-forestry shrub)	142	45%	93	46%
Bushland (includes shrubland)	32.9	10%	30.8	15%
Forest (includes open woodland)	30	10%	35	17%
Cropland	36	11%	13.6	7%
Woodlot	2.1	1%	0.3	0%
Pasture	49.2	16%	20.3	10%
Other (Includes barren land, rocks, urban, water bodies)	23.8	8%	7.5	4%
TOTAL	316.1		200.5	

The table above shows another perspective on the breakdown of land use by slope class (over 30% slope based on Haitian legal codes) and by the average elevation in the region (over 350 meters). This table shows that a large portion of the area with slopes higher than 30% (45%) are currently being used for agroforestry, which is generally recommended for anti-erosive practices. While 11% of land with slopes higher than 30% are covered with forests and woodlots, the analysis also shows that over 26% is being used for agriculture (including cropland and pasture).   These are broad priority areas for MARNDR and South Department policy to increase strategic efforts for perennial hillside agriculture, most often agro-forestry and woodlots, as well as to craft programs and strategies to increase forest cover in priority areas.

The breakdown by elevation also shows that in high elevation areas (over 350m), the most widespread use of land is agro-forestry, at 46% of the area, while only 17% of the area is classified as forest.

Nine communes of the southwest coast

More detailed analysis is available for the nine communes of the southwest coast. The Earth Institute broke down LULC analysis across agro-ecological zones, illustrating that 59% of the nine-commune area is classified as dry-agriculture and fishing. The remainder of the area is broken down into the agro-ecological zones of humid-mountain (28%) and agro-pastoral (13%).

According to the results of the LULC image analysis, most of the land classified as dry-agriculture and fishing is used for agro-forestry[2] (43%) followed by pastureland (21%) and cropland (15%). Low-elevation areas, where the vast majority of the population within the nine-commune region lives, are also classified as dry-agriculture and fishing.

Land use/ land cover classification, condensed.	Agropastoral Area (%)	Dry ag area (%)	Humid area (%)	Total 9 commune area (%)
Agroforestry (includes agroforestry-shrub)	47%	43%	40%	43%
Bushland (includes shrubland)	11%	6%	14%	9%
Forest (includes open woodland)	4%	2%	30%	10%
Cropland	11%	15%	5%	12%
Woodlot	3%	1%	0%	1%
Pasture	17%	21%	7%	17%
Other (includes barren land, rocks, urban, water bodies)	7%	11%	4%	9%
Total	**100%**	**100%**	**100%**	100%

Table 4 Land Use and Land Cover by Agro-Ecological Zone

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[2] Includes agroforestry-shrub

Legend
- Agroforestry
- Agroforestry-shrub
- Barren land
- Bushland
- Cropland
- Forest
- Open woodland
- Pasture
- Rock
- Shrubland
- Urban
- Woodlot
- Water bodies

| 0 | 5 | 10 | 20 | 30 |
Km
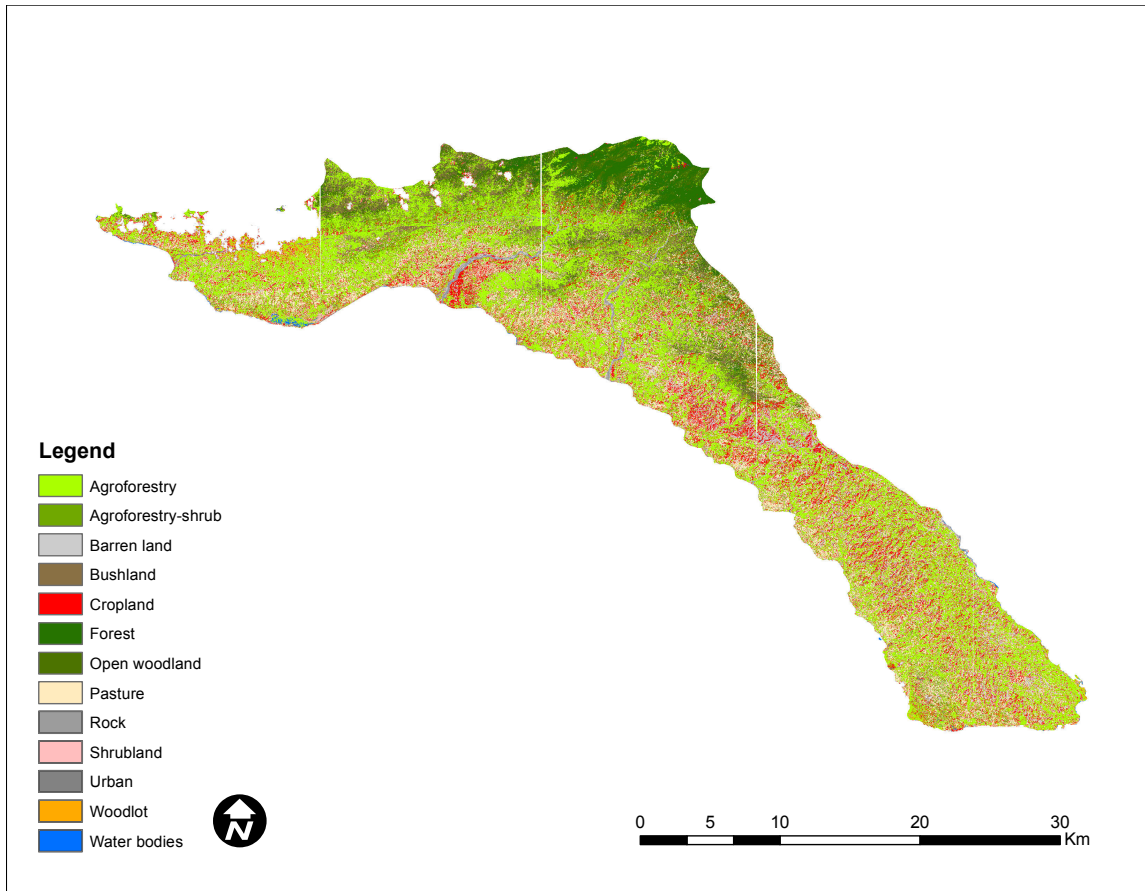
Map 4 Land use and land cover for the nine southwest coast communes.

The spatial analysis found that within the nine communes, the dominant land cover and land use is agro-forestry at 34%[3] followed by pasture at 17% and cropland at 12%.

As is the case for the entire South Department, the agro-forestry classification was usually accompanied by cropland, bushland and shrubland. Similar studies conducted throughout the region[4] confirmed that the practice of agro-forestry is usually implemented in the same plot where crops are being harvested and livestock is being raised. As a result, ad-hoc land use management practices pose interesting challenges to achieve concerted regional planning in the area.

Forest represents only 4% of the total landscape. Pastureland in the region is often fallow cropland, used for grazing; pastureland represents 17% of the landscape whose productivity can be improved by adopting land use management practices that correspond to sustainable cultivation.

According to LULC survey, almost three quarters (73%) of the nine communes is under some form of agricultural production, including annual food cropping, agroforestry and pasture. More

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[3] Does not include the agro-forestry shrub class.

[4] Please consult http://cgsd.columbia.edu/projects/haiti-research-and-policy-program/ for other available reports and studies conducted on this matter.

than half of the land area is cultivated with inter-cropping, including the agroforestry and agroforestry shrub classification, which encompasses 47% of the region. The 2011-2012 Integrated Household Survey, available separately, shows that 88% of households in the nine communes of the southwest coast and Ile à Vache report inter-cropping during the last harvest[5]. Imagery shows that a large total number of parcels have vegetative cover and a predominance of cultivated land.

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[5] While this percentage was reported by the household survey, satellite imagery can not discern this in the land use land cover map.

Port-à-Piment Watershed

The Port-à-Piment watershed is a subset of the South Department region and the nine-communes southwest coast zone. The watershed as a unit of analysis is critical as it allows for evaluation of the land management practices that have direct impacts on water flow, erosion dynamics, and water absorption. Located at the base of the Pic Macaya National Park, the Port-à-Piment watershed is a priority zone and a highly vulnerable sub-watershed within the larger Tiburon hydrological system and focus of extensive interventions under an integrated development model from the same funders of this report. Thus there is the potential to see large changes in 5 years if investment and the interventions are sustained. Illustrating the priority of this zone, 40% of the forest cover for the entire south department is located with the boundaries of the Port-à-Piment watershed.

As the Pic Macaya National Park is legally protected and one of the last vestiges of forest cover in the country, the land use and land cover mapping of the zone immediately surrounding the upper boundaries of the watershed are important for analysis. The land use practices in this watershed zone are important to contextualize the remaining forest cover as well as the practices and pressures surrounding the protected area.

Only 14% of the total landscape is covered in woody vegetation, either trees or shrubs, and of this only 4% is closed canopy forest, most of which is located in the Pic Macaya zone of the upper watershed. This lack of forest cover poses a threat to the availability of several ecosystem services. The remaining landscape vegetation is not likely to protect the soil and meet the demand in wood for cooking, charcoal production and timber throughout the watershed.

Within the Port-à-Piment watershed, the dominant land use is agro-forestry, at 27% of the overall area. As at the departmental and southwest coast level, this high incidence of agro-forestry is related to the high rate of intercropping as an agricultural practice in the region.

Table 5 LULC classification, Port-à-Piment watershed		
Class	Area (km2)	Area(%)
Agroforestry	27	27%
Agroforestry-Shrub	14	14%
Barren Land	4	4%
Bushland	11	11%
Cropland	9	8%
Forest	4	4%
Open Woodland	10	10%
Pasture	16	16%
Rock	1	1%
Shrubland	3	3%
Urban	2	2%
Woodlot	0	0%
Clouds	0	
Water bodies	0	0%

The high incidence of the agroforestry classification is contrasted with rates of formal crop cultivation (the cropland cultivation) that fall below the regional average, at only 8% of the area. Formal cropland classification is more difficult in a mountainous terrain; in the 2011-2012 household survey, only 19% of plots are located on flat land at the bottom of hills. This reinforces the reliance on intercropping and steep-slope agriculture; this can be problematic in the watershed, as the majority of the area (64%) is comprised of lands with slopes above 30%. Relating to the agroforestry designation, as of 2011-2012, 40% of households in the watershed reported

planting trees. However, the majority of parcels, defined as continuous pieces of land that farmers identify as one unit, at 82% have no conservation methods employed to preserve soils, despite the fact that 50% of all parcels are located on the side of a hill.

The practice of annual cropping, on the steepest terrain, will continue to cause severe soil erosion and destructive sedimentation and flooding downstream unless addressed. Unabated soil erosion will eventually limit rooting depth and deplete nutrients required for crop productivity.

For lands not classified as formal cropland or agroforestry, however, the watershed shows a larger percentage of the overall area considered bushland (11%) and open woodland (10%) than the rest of the region.
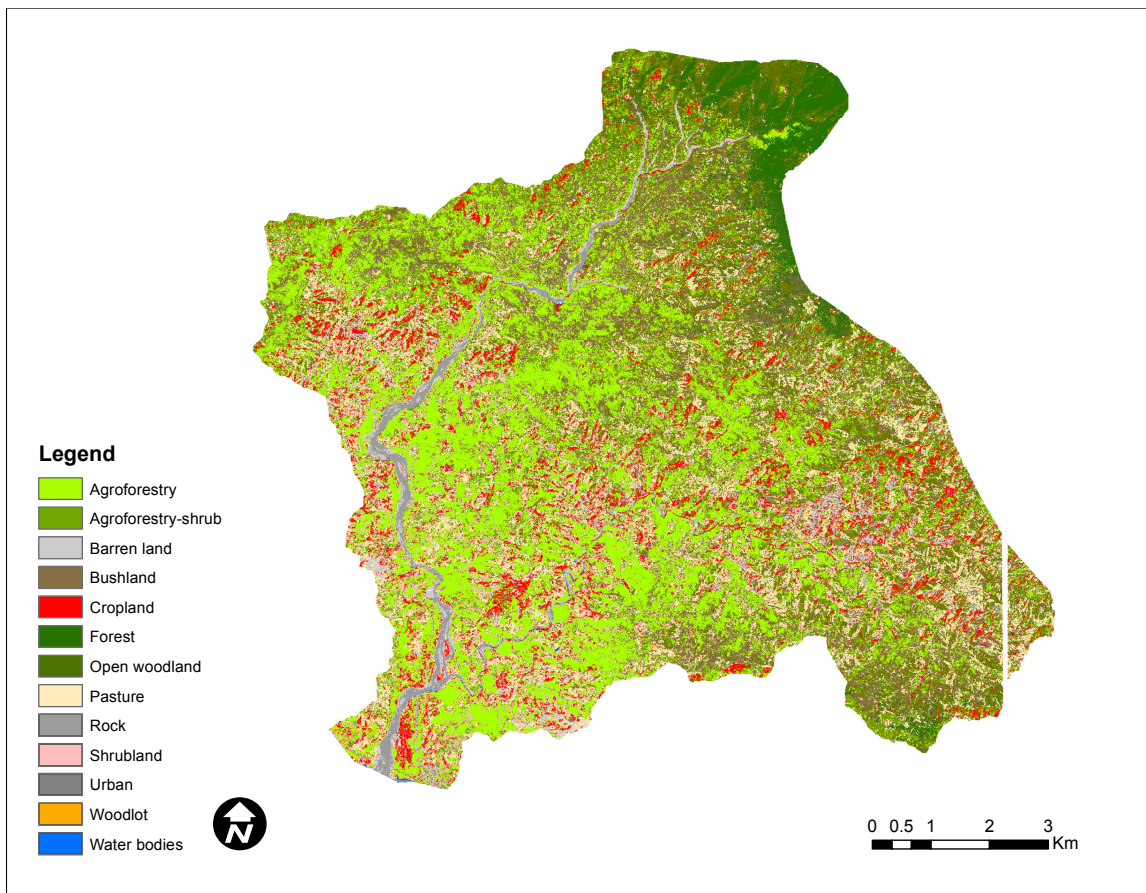
Map 5 Land use and land cover map for the watershed of Port-a-Piment

Qualitative observations in the Port-à-Piment watershed suggest that flat lowlands have the highest agricultural productivity, additional information is available in the integrated report. This was further analyzed by the Organization for the Rehabilitation of the Environment (ORE) and EI during trials of bean varieties and hillside conservation techniques. Give the pressure on land related to the socio-economic context of watershed, the study

recommended that different cropping systems be established in level (0–16 %) moderate (16–30 %) and steep slopes (>30 %). Parcels with level slopes would be ideal for intensive annual, mixed or mechanized cropping, requiring no, or few conservation measures. The researchers recommended and identified the zones where agroforestry, including annual crops (maize, beans) may be intercropped with semi–permanent (e.g., *Cajanus cajan*), or permanent crops (e.g., fruit trees) is the preferred activity due to moderate slopes. Nonetheless, intensive conservation techniques (e.g., vegetative barriers, mulching, narrow ridges and furrow, rock wall contours) would be required to prevent soil erosion. If the slope exceeds 40%, the risk of soil erosion is very high and it is recommended that these sites be ungrazed and planted with trees to allow vegetation to regenerate.

Similar combinations of LDSF and LULC studies are recommended to deepen the efficacy of the LULC studies for the nine-commune southwest coast and for the South Department and to make more accurate crop optimization modeling.

Brief recommendations

The exercise of creating a LULC dataset and beginning the preliminary rounds of analysis has generated in ideas put forward for consideration by our partners and the local communities. This report is meant to be a launching point for discussion for an ongoing planning process with stakeholders in the region as they formulate the program priorities and craft approaches towards increasing agricultural productivity and environmentally sustainable systems in the South Department.

This report estimates the total hectares of land that are on slopes greater than 15% and help deduce current land use and land cover practices within these zones. This analysis leads policy makers and researchers to identify the areas which permanent tree cover or improved soil conservation techniques should be targeted. Elsewhere, including the 2011 LDSF report, approaches identified to achieve this end include using perennial agro-forestry and other conservation infrastructure. These areas can be prioritized for reforestation for timber and conservation activities and help create estimates of total area and costs required to address these challenges at a meaningful scale.

As shown in 2011 LDSF report, deforestation in steep areas has been so extreme that the soil is completely eroded; crop and tree production and soil fertility improvement programs will only be effective when soil conservation and in some cases soil re-building is effectively addressed at a large enough scale to impact micro-watershed areas. The LDSF report, conducted in the Port-à-Piment watershed, demonstrates the high variability of soil quality and erosion potential within a region. Accordingly, it is recommended that similar LDSF studies are undertaken on a larger scale for tailored approaches to increasing yields and identifying most promising approaches to environmental sustainability, particularly in high-risk areas.

Past tree planting programs have focused at smaller scales, usually on individual plots and farms. This has brought limited success in terms of care and survival of trees and wide scale adoption. It has also often neglected to address the need for coverage of contiguous larger sub-watershed basin and hillside reforestation efforts. Communities and farmers need to be sufficiently involved in the planning process, decision-making, and implementation and to have sufficient ownership of and responsibility for project outcomes.

The results of this mapping should be shared with communities and integrated into participative planning processes by the government and their partners. The Port-à-Piment watershed was specifically chosen as a pilot region to use this material as part of the long-term integrated development project, reinforcing the existing capacity of the local community development groups, watershed management organizations and agricultural cooperatives. The results should help develop a detailed land use management plan based on a participatory planning process. This could be paired with open-source and crowd-sourcing technology to help advance ongoing monitoring and field based monitoring by the community itself.

This data has the potential to highly useful for MARNDR regional experts in cooperation with regional extension agents, university students, and technical institutes to identify target different tree planting categories, according to land use and land cover. The land use and land cover map can also be combined with land degradation, elevation and slope data to help craft a

tree planting goals and strategies, considering agro-ecological zones, current land use categories, and estimate land degradation potentials.

Initial models and estimates for targeted tree planting in these three areas on deforested hillsides with slopes greater than 15% is roughly 400,000 ha (see table below). An integrated strategy for tree planting in these areas should be developed by MARNDR and in a participatory manner with communities to target reforestation on slopes >15% and along streams and rivers. The land use map can help identify priority areas at regional and local scales.

Agroforestry and woodlots in areas could be targeted on slopes between above 15%, with a strict focus on areas with slopes greater than 30%. The mix between the three strategies would depend on the landscape and farm distributions. An ambitious goal would be to reach 50% of the area to trees in the next ten years. The LULC data above show that the department is on track for reaching a majority of area under agro-forestry, but the manner of intercropping and the lack of protective soil-conservation infrastructure as measured by the household survey imply that there are best practices that need to be implemented to ensure environmental viability. Additionally, the South Department is far from target levels with forest cover or woodlots.

Preliminary Estimates: Trees required and cost to target 25% of area with slope >15%

Priority regions	Number of reforestation trees	Number of woodlot trees	Number of agroforestry trees	Cost at $0.14 per seedling
South Department	**(200 trees/ha)**	**(400 trees/ha)**	**(100 trees/ha)**	
	2083949	4167898	1041974	$1,021,134

Please note the costs and estimates above are not conclusive. These are preliminary estimates meant to serve as a basis for discussion amount regional policy makers.

The maps produced by this report are only visualizations of a robust dataset, and should serve only a base map for communities and MARNDR to designate priority reforestation areas based on their analysis and priorities for agricultural growth and natural resource management objectives. This data collection and mapping process should be repeated in 5 or 10 years for an objective, landscape scale review. The data and its corresponding visualizations should be used as part of a multi-tool monitoring program. The data and its maps can be used in addition to mobile tools, such as ICT4Ag, which allow for continuous crop monitoring and farmer level support and data collection.

Potential priority areas:

- Focus interventions for forest conservation in the targeted remaining forested areas.

The total forested area in the region with 63km2 represents only 3% of the land cover. The area adjacent to the Port-à-Piment watershed hosts 40% of the remaining forests, and therefore should be a priority for forest conservation policies. In the next year of programming, reforestation programs, including nurseries and hillside conservation programs, should be geographically defined on the buffer zones of these areas.

- The maps can provide a basis to demarcate cropland and pasture.

Using these maps and the data could identify the areas with slopes greater than 15% slope as target zones for transition from steep slope cultivation into perennial woodlots and agroforestry, around crops identified in the market studies and community consultations (woodlot, agroforestry). Cropland and pasture on steep slopes should be replaced by perennial systems (woodlot, agroforestry)

- Use the land cover map to sensitize the community to its environment

Community mapping exercise often does not include formal land cover maps. By working with both, a participatory map and a formal land cover map, and linking both maps using point of interests

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L'OCCUPATION DU SOL ET COUVERTURE DE TERRE

DEPARTEMENT DU SUD

Légende:
- Fôrets
- Systèmes agroforestiers
- Pâturages avec présence d'autres occupations
- Cultures agricoles
- Savanes
- Plans d'eau

0   10   20 Km

La classification complète a été simplifiée en six catégories principales, à des fins de représentation.
Les zones en blanc représentent d'autres types d'occupation des sols.

Sources des données: l'occupation du sol et couverture de terre de Earth Institute et al (2012); localités de IHSI (2006); hydrographie de CNIGS (2004); les zones agro-écologiques de USAID/ FEWS NET (2010).
Production de la carte: Center for International Earth Science Information Network CIESIN, Earth Institute at Columbia University.
Système de coordonnées géographiques: GCS WGS 1984. Projection: UTM Zone 18N
Unités: mètres
Date de création: Juillet 2012

CIESIN ne donne aucune garantie de représentation quant à la fiabilité ou l'exactitude des données contenues dans ce document. Cette carte est destinée à être utilisée aux fins de planification seulement.

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LES ZONES AGRO-ECOLOGIQUES
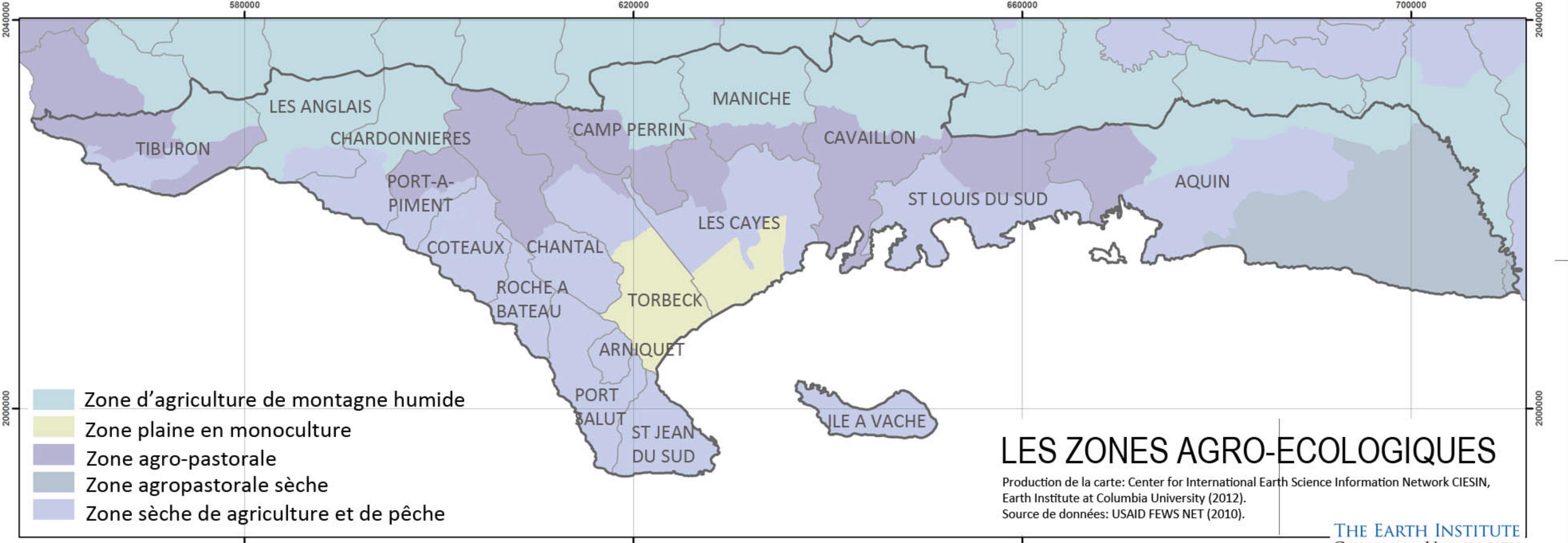
Légende:
- Zone d'agriculture de montagne humide
- Zone plaine en monoculture
- Zone agro-pastorale
- Zone agropastorale sèche
- Zone sèche de agriculture et de pêche

Production de la carte: Center for International Earth Science Information Network CIESIN,
Earth Institute at Columbia University (2012).
Source de données: USAID FEWS NET (2010).

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Localités / Communes mentionnées:

Irois, Galette Sèche, LES ANGLAIS, Nan Saint, CHARDONNIERES, Tiburon, Les Anglais, TIBURON, PORT-A-PIMENT, Port-a-Piment, COTEAUX, Coteaux, TORBECK, Bourjoly, Ducis, CHANTAL, ROCHE A BATEAU, Dubois, ARNIQUET, PORT SALUT, Port Salut, ST JEAN DU SUD, Saint-Jean, Marceline, CAMP PERRIN, Caudere, Bauzan, LES CAYES, Generes, Les Cayes, Carrefour Méridien, MANICHE, Laurent, Nan Cotie, Balou, CAVAILLON, Cavaillon, ST LOUIS DU SUD, Saint-Louis-du-Sud, Lasile, Bojo, Carrefour Moussignac, Ca Michaud, Quartier, Aquin, Mar Morne Aquin, Ti Raisin, AQUIN, Guêpe, Coquille, Laborieux, Grangou, ILE A VACHE

Baie des Anglais, Mer des Caraïbes, Baie des Cayes, Canal du Sud

L'OCCUPATION DU SOL ET COUVERTURE DE TERRE

Map coordinate labels (top): 560000 · 580000 · 600000 · 620000
Map coordinate labels (left/right): 2020000 · 2000000

Region labels on main map:
TIBURON · LES ANGLAIS · CHARDONNIERES · PORT-A-PIMENT · COTEAUX · CHANTAL · ROCHE A BATEAU · ARNIQUET · PORT SALUT · ST JEAN DU SUD · CAMP PERRIN · MANICHE · LES CAYES · TORBECK

Water bodies:
Baie des Anglais · Mer des Caraïbes · Baie des Cayes

Localities:
Ville de Tiburon · Nan Sable · In Bono · Blanchard · Bon Pas · Ville des Anglais · Dufou · Liserna · Verone · Terre Blanche · Cabatol · Saint Alba · Fierville · Randel · Cavalier · Guillaume · Balais · Remy · Ville de Chardonnières · Bousquette · Grande Passe · Morne Sinaï · Ville de Port-à-Piment · Figuier · Damassin · Cassitte · Ville de Coteaux · Dimanche · Lamarre · Ville de Roche a Bateau · Fortena · Gd Droit · Ville de Arniquet · Carrefour Joute · Carpentier · Bergerac · Exanina · Ville de Port Salut · Djo · Divo · Dumond · Elois · Boyer · Ville de St Jean du Sud

LES ZONES AGRO-ECOLOGIQUES

- Zone plaine en monoculture
- Zone agro-pastorale
- Zone d'agriculture de montagne humide
- Zone sèche de agriculture et de pêche

Production de la carte: Center for International Earth Science Information Network CIESIN, Earth Institute at Columbia University (2012).
Source de données: USAID FEWS NET (2010).

Legend (main):
- Fôrets
- Systèmes Agroforestiers
- Pâturages avec présence d'autres occupations
- Cultures agricoles
- Savanes

La classification complète a été simplifiée en cinq catégories principales, à des fins de représentation. Les zones en blanc représentent d'autres types d'occupation des sols.

Sources des données: l'occupation du sol et couverture de terre de Earth Institute et al (2012); localités de IHSI (2006); hydrographie de CNIGS (2004); les zones agro-écologiques de USAID/ FEWS NET (2010).
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L'OCCUPATION DU SOL ET COUVERTURE DE TERRE DANS PORT-A-PIMENT

Carte labels:

CHARDONNIERES

PORT-A-PIMENT

CHANTAL

COTEAUX

Source Gresson
Cabatol
Saint Alba
Fierville
Randel
Cavalier
Balais
Guillaume
Remy
Grande Passe
Morne Sinai
Ville de Port-a-Piment
Saradas

LES ZONES AGRO-ECOLOGIQUES

Zone d'agriculture de montagne humide

Zone agro-pastorale

Zone sèche de agriculture et de pêche

Légende:

- Fôrets
- Systèmes Agroforestiers
- Pâturages avec présence d'autres occupations
- Cultures agricoles
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- Plans d'eau

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0   2.5 Km

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