[OLD]
Methodology for overall identification, prioritization and selection
[from proposal:
In consultation with the GoBL, the SEC consultancy, and a broad representation of stakeholders (as identified in Activity 1.1), we will scope the ecosystem services most relevant to the policy issues and development alternatives under consideration. We will first compile a list of services based on the values of greatest importance to stakeholders and the objectives of the planning process (e.g., eco-tourism, forestry, agriculture, water security, and cultural values are likely critical). Second, we will use the peer review literature, and our broader experience in the LAC region, to add potentially important services to this list. Third, we will compare this list with the development and management issues to identify a shorter list of high priority services most likely to be affected by alternative development trajectories. We will aim to choose four to five services from this list, a number that tends to be manageable and accessible within real policy processes.

The InVEST model suite includes models for several of the important benefits that the CMCC Region's ecosystems provide to people: InVEST hydrological models quantify water supply and the regulating services of filtration and avoided sedimentation, based on changes in land uses and land cover (Hamel and Guswa 2014, Guswa et al. 2014, Sharp et al. 2018), as well as hydrologic regulating services that control local recharge and dry season water availability. InVEST includes approaches for estimating agriculture and timber production (Goldstein et al. 2012, Sharp et al. 2014), and carbon models to estimate storage capacity and social value.

If other services are identified for which InVEST models do not currently exist, we will apply and modify, as necessary, existing quantitative approaches to assess the contributions of those services to communities, for example with GIS overlays, spatial statistics, water balance models, etc.

We will generate maps and report model outputs at three resolutions: (1) finest scale for each service, determined by data availability (for example, carbon storage, water yield and water quality metrics are often reported at 30m resolution, whereas tourism/recreation are often estimated at a resolution of 1 km grid cells); (2) 'deep dive' focal regional scale, to be identified based on stakeholder consultations and relevant policy and development options; and (3) coarsest scale, summarizing results for all services for the entire

CMCC Region. The result will be georeferenced ecosystem service supply maps for the CMCC Region, along with relevant metadata to facilitate uptake beyond the life of this project.

List of ES/development objectives to consider (from project team convos)
Tourism
- quality of the experience - adventure, remoteness, some place special
- delivery of specialized and premium product to overnight (not cruise) visitors.

Cultural heritage
- preservation of archaeological sites
- caves
- other sacred sites?

Timber
Mining (is this an ES? It may definitely be a trade-off)
Water
Recharge zones
Energy production (from water)
Agricultural production/pollination/food security

Issues of safety/security underpin a lot of the development goals, for communities and for tourism

Background info/notes
Primary economic activities within the CMCC includes tourism, timber extraction, mining, and power generation. Historically, timber extraction served as the economic raison d'etre for the CMCC; today, economic development in the region is underpinned by the growing tourism industry. Currently an average of around 10,000 visitors/year visit the Caracol Archeological Reserve – about 1/8 of the total visitations to neighboring San Ignacio Town. Improved road access therefore is expected to have a resulting increase in visitors to the region. (Williams mid-term report to IDB May 2018).

Overall three other the key policy and development issues arose across the board in this initial scoping: that **the SDP must focus on retention/enhancement of the ES of the CMCC**, that **land governance, tenure and management systems need to be resolved**

and improved, security and safety concerns, and the need for articulation and better synergy between all stakeholders involved in the management and governance of the CMCC. Ultimately stakeholders see the development of the SDP as an opportunity to ensure that ES services of the CMCC are maintained while bringing economic and development opportunities for locals. (Draft Stakeholder Engagement Strategy May 2019)

what does "sustainability" mean in this context to these stakeholders?

Post-workshop planning

Ecosystem services to address in the SDP (semi-final list):

Service	Analysis approach	Notes/Qs	Beneficiary	Point person
Seasonal water flow	InVEST Seasonal Water Yield	Baseflow (Qb) - how much livestock is kept on the avg farm? - Where do arch sites get their water (rain or river?) - Where do resorts get their water (river or groundwater?) - Tourism expenditures? Local recharge (L) [use as an index to show impacts]	Qb: Hydroelectric dams Tourism/swimming, tubing, rafting sites Communities (water supply) Resorts (water supply) Archaeological sites (water supply) Irrigated agriculture Water for livestock Environmental flows for aquatic ecosystems/fishing L: Shallow water wells	Model: Stacie Beneficiaries:

Water quality	InVEST NDR	N and/or P? data on fertilizers will be important bacteria (E. coli)/trash? have any studies done a correlation between tourism and water quality issues?	Water supply for - communities - resorts - tourism/swimming areas	Model: Marcelo Beneficiaries:
Tourism/recreation	Include scenarios of tourism development in different places, calculate impacts on water, ecosystems, conflicts with other services. Include expansion of footprint and these impacts? Perhaps model accessibility and impacts on ecosystems?	Perhaps model different tourism development options as scenarios. Look for other accessibility study, show which places are more or less accessible based on roads network.	Private investors Resorts Communities GoB	Analysis: Adrian
Habitat/ecosystem	InVEST Habitat Quality	Use the cumulative disturbance from the HQ model as an index of impact Need threat layers:		Marcelo

		roads, trails (official and unofficial), gold panning areas, illegal logging, granite and gold mining (legal and illegal) etc.		
Timber				
Pollination				Stacie: talk with Elma about data available, see if it's worth pursuing this model.
Soils				

Scenarios
Agricultural expansion
Increase in contamination from Guatemala
Mining expansion - gold and granite
Illegal extractions (timber, gold panning, poaching)
Road construction
Tourism development
Expansion of recreation (unregulated)

Constraints
For ag expansion: limit to areas suitable for crops. Crop suitability map from BNSDI (but we cannot yet download it and we don't know what the legend means) Someone at workshop mentioned a farming study looking at what are suitable areas - can we get this?

TO DOs
- Land cover map: use Stacie's existing merged map for now, incorporate perennial, annual, fallow into it; get more detail on agriculture if/when we can and incorporate this into map and/or biophysical table parameters
- DEM - ASTER SRTM: need to fetch other tiles to cover Guatemala, Stacie and Marcelo will work together to get SRTM data and process it into the DEM for the AOI
- AOI - need to re-delineate AOI based on 30m DEM, add a buffer. For now use the same pour point slightly upstream of Belmopan.
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Nov 5, 2019
METHODOLOGY FOR EVALUATING THE IMPACTS OF DEVELOPMENT OPTIONS

1) Define the important ecosystem services
    a) inputs: stakeholder feedback
2) Define the major land use changes that will impact the area
    a) inputs: stakeholder feedback from workshop 1 and workshop 2
    b) List of drivers:
        i) Agriculture
        ii) Mining
        iii) Timber
        iv) Tourism
        v) Renewal energy development
3) Model the impacts of each of these changes everywhere they are possible
    a) Baseline LULC raster and biophysical table for each ecosystem service model
    b) Baseline model results for each ecosystem service and existing landscape
        i) nutrient retention
        ii) seasonal water yield
        iii) tourism
    c) Define where are all these changes possible? What is the maximum possible scope for these activities to expand?

i) method: review stakeholder workshop maps for worst-case scenarios in 20 years, focusing on changes envisioned for each driver/change.

 (1) Agriculture (Stacie)
  (a) draw limits based on
   (i) stakeholder-drawn maps, visual analysis of all maps from workshop 2 (20-year worst case scenarios + 20-year BAU scenario from Friday) and digitalize an "average" limit to the expansion
   (ii) slope threshold: ask agriculture expert what a realistic slope threshold is
  (b) which types of agriculture will expand into the new areas? This will be based on considering major areas/actors expanding, each of these will be associated with a particular crop or pasture practice: (and also considering baseline agriculture polygons)
   (i) expansion from Guatemala
   (ii) expansion of Mennonite ag areas
   (iii) expansion around farming villages
   (iv) how exactly does milpa work? is there a rotation within a given area, or are areas abandoned permanently after initial cropping? (ask someone local about this)
 (2) Mining (Marcelo)
  (a) mining in Caves Branch river is out of our study area, will not consider
  (b) in Chiquibul National Park, define the limit of mining expansion based on visual analysis of maps from workshop 2 (20-year worst case scenarios + 20-year BAU scenario from Friday) and digitalize an "average" limit to the expansion
  (c) change all of the resulting polygon to bare ground/mining (any other parameters to consider? MG will look for geology map, talk to Denver about other parameters to consider)
 (3) Timber (Marcelo)
  (a) use the limits of the Mountain Pine Ridge/timber ecosystem area, Chiquibul Forest Reserve and 5km buffer around it. Not allowed in the rest of Chiquibul National Forest.
 (4) Tourism/Development (Marcelo)
  (a) Narrow buffer along planned road of "urban" (hotels, shops, etc.) - 60m on each side
  (b) Wider buffer around that of agriculture - 500m buffer around road
  (c) Buffer around tourism sites - 500m
   (i) Puente natural

          (ii)   Barton Creek cave

          (iii)   (other points in our shapefile of assets and opportunities - TBD)

          (iv)   Chalillo lake

       (d) output: LULC map for each activity expanded to its maximum extent, overlain with the current LULC map

   d) Run InVEST models with the new LULC maps and evaluate impacts

       i)   parameterize models for land use changes, any changes to biophysical tables

       ii)   run scenarios

       iii)   calculate the change in each service for each land use change

4) Compare the impacts to see which areas are more or less impacted by different development options/drivers.

TO DOs by model as of 12 Feb 2020

(notes from convo with Stacie + Adrian Feb 12)

InVEST version 3.8.0 will be used to finalize all models for this project.

Overall:

- run SDR model with v3.8 to see if the stream network changes, and/or try to burn in streams or find another way to force the stream network to look better [SW]

NDR model:

- review the dam retention method used in Narragansett Bay and see if it can be applied here [AV]
- delineate the watershed using the most downstream point (San Ignacio) [SW]
- calculate long-term annual average nitrogen load at "downstream sites" group:
  - calculate the average annual flow for 2016-18 from compiled flow records (L/yr) [AV]

- ○ use the flow to calculate load [SW]
- what do we use for runoff proxy? TBD based on results of SWY model "calibration"
- review methods used for Narr Bay project and come up with a sensitivity analysis method [AV+SW]
- run sensitivity analysis and determine final parameter values [SW with input from AV]

SDR model:

- review sediment data and see if dam retention is a significant thing that we need to consider [AV]

Tourism:

- propose method for developing tourism scenarios, estimating output metrics based on those scenarios [MG?]

Agriculture:

- review literature on crop yields and values provided by MG [BPB]

Proposed methodology for hybrid scenarios 4 Apr 2020