Rice Brings Lights
Biomass Electrification Suitability in Cambodia

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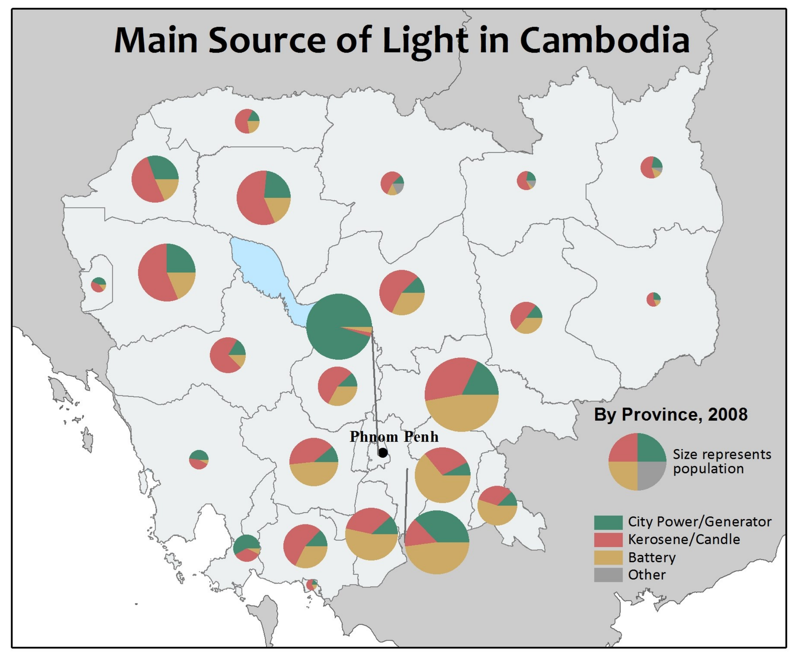
Date: **May 9, 2017**
Projection: **WGS 1984 UTM Zone 48N**
P207 GIS for International Applications

Background

In Cambodia, many rural people still use kerosene or batteries as the main source of light because of the poor supply and high price of the electricity (see map below). The government of Cambodia has set a target of 70% of total household to have electrification with grid-quality electricity by 2030, and mini-grid establishment based on renewable energy has been one of the pillars of the national policy. Among others, biomass has recently attracted much attention, because the large agricultural sector has annually produced an abundance of residue that could be used for electricity generation instead of diesel. As many rural people engage in agriculture, biomass has a potential for benefiting them as well.

Main Source of Light in Cambodia



This study focuses on *rice husks* as one of the promising biomass resources, as rice is a stable food of Cambodia and the largest agricultural sector. The purpose of the study is to **identify suitable areas for installing biomass power plants which utilize rice husks** to provide electricity to local people by establishing mini-grid systems. In order to establish feasible and sustainable systems from the business perspective, targeted people are those who can afford electricity cost without additional financial aid[1]. The impact of biomass electrification is also evaluated. The time period of main data is 2008.

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Suitability Factors

Electricity Need

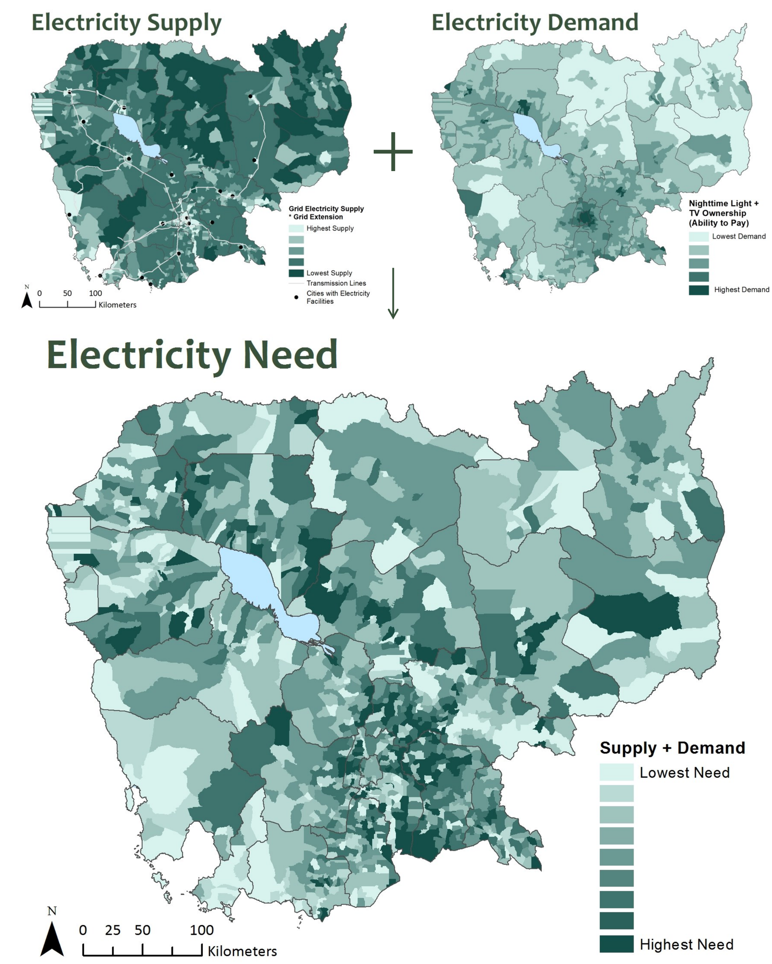
Electricity supply and demand situations were analyzed in combination to illuminate areas where there is high demand for electricity but grid-quality electricity is not available.

<u>**Electricity supply**</u>: 1 (highest) to 5 (lowest)

- Households whose main source of light is either city power, generator, or both of them were thought to have grid-quality electricity supply.
- Communes within the technical limit of 40km from cities with electricity facility have the possibility of future grid extension[1] and less suitable.
- Supply score = grid electricity supply * grid extension possibility (0.8 if possible, 1 for not)

<u>**Electricity demand**</u>: 1 (lowest) to 5 (highest)

- High level of light usage at night indicates high demand in electricity, whatever the source is.
- Television ownership was used as a proxy for a high electricity demand and a capacity to pay[1].
- Demand score = average of the two scores



Biomass Potential

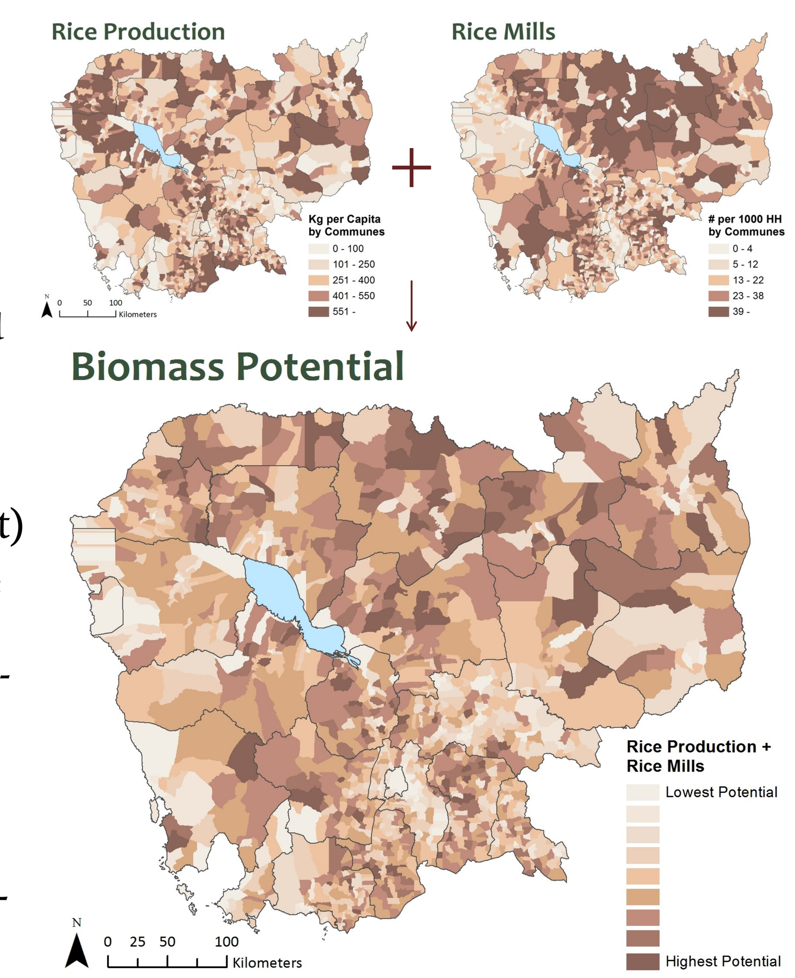
Two factors were used for biomass potential.

<u>**Rice production**</u>: 1 (smallest) to 5 (largest)

- Potential for biomass resources can be estimated by the yield of the crop[2]. Rice production per capita was used to estimate the potential for rice husks for biomass electrification.

<u>**Number of rice mills**</u>: 1 (smallest) to 5 (largest)

- Harvested rice are gathered at rice mills and rice husks are produced in rice mills. The number of rice mills per 1000 household was used as another indicator for biomass potential.



Physical Condition

Three factors were considered as physical condition for business suitability in Cambodia.

<u>**Road proximity**</u>: 1 (farthest) to 5 (nearest)

- Distance from roads was used for measuring transportation costs[3].
- National and provincial roads were weighted twice compared to the rural roads.

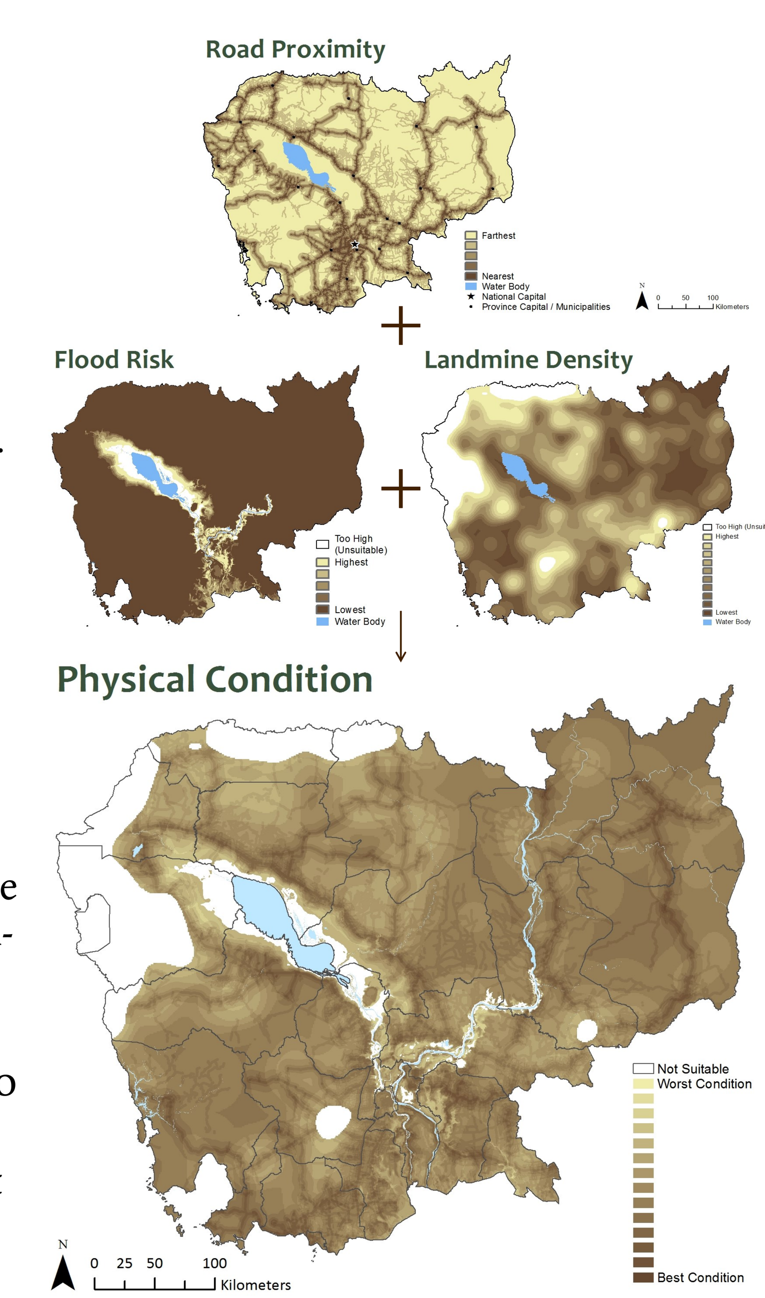
<u>**Flood risk**</u>: 1 (largest) to 5 (smallest)

- The estimated inundation depth of major flood caused by the Tonle Sap (Great Lake) and the Mekong River was used for evaluating flood risk.
- The riskiest areas where the depth is over 5 meters were eliminated from the analysis, as such depth causes more than 50% damage to a building[4]. Other areas were classified using the depth.

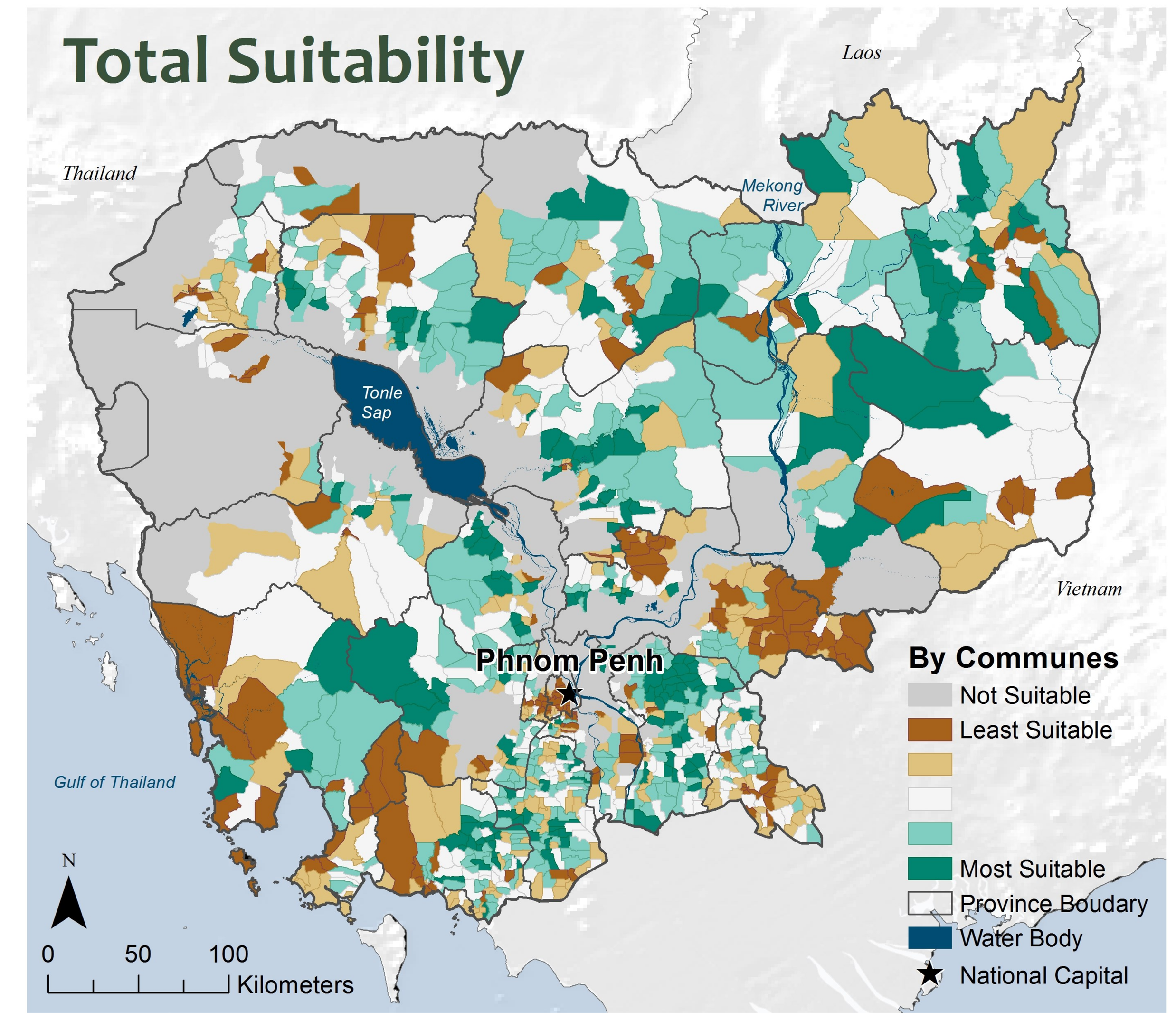
<u>**Landmine density**</u>: 1 (highest) to 5 (smallest)

- As a country with a recent history of war, hazardous landmines location should be taken into consideration[5].
- Based on the reported locations of landmines, the riskiest areas (top 10% kernel density) were eliminated from the analysis, and other areas were classified by the density.

The three physical indicators were combined to produce raster data showing physical suitability, which was then converted to vector dataset based on the communes to combine with two other factors.



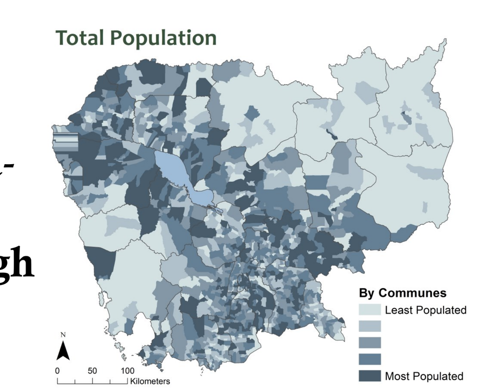
Results



The feature map shows the total suitability by communes. The total suitability was produced by adding the seven attributes consisting of the three factors with equal weight. The result shows that the high-scored communes are generally dispersed across the country, but the risk of flood and landmine hinders the electrification opportunities especially in the north-west region and around the water bodies.

Impact of Electrification

To see how effective the introduction of biomass power plants will be, the population data was used in combination with the suitability. **Communes with both high suitability and large population** are the best for biomass electrification.



The maps and the table on the right show the summary of such communes. Out of the communes with highest total suitability score, communes with population more than 8,264 people (above mean in 2008 by Census) were selected as "**the 10 communes**" most suitable and largest potential benefit for people in Cambodia. The listed communes have high scores for each factor on average, but communes differ in each factor score as well as the population size. Policymakers can use this information to consider the costs and benefits of biomass electrification.

Limitations

Data consistency would be a limitation of this study as the data collection method and accuracy of the two main data sources (Population Census and Commune Database) may differ. The inundation depth was not available around the northern part of the Mekong River, so the risk may be underestimated in this region.

Literature Cited

1 Abe, Hitofumi, et al. "Potential for rural electrification based on biomass gasification in Cambodia." *Biomass and Bioenergy* 31.9 (2007): 656-664.
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3 Knolan, Katherine. 2014. *Bringing Light to Uganda: Off-Grid Electricity Suitability Map.* Medford, MA: Tufts GIS.
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5 Hill, Rebecca Lee, and Kevin M. Curtin. "Solar powered light emitting diode distribution in developing countries: An assessment of potential distribution sites in rural Cambodia using network analyses." *Socio-economic planning sciences* 45.1 (2011): 48-57.

Data Sources

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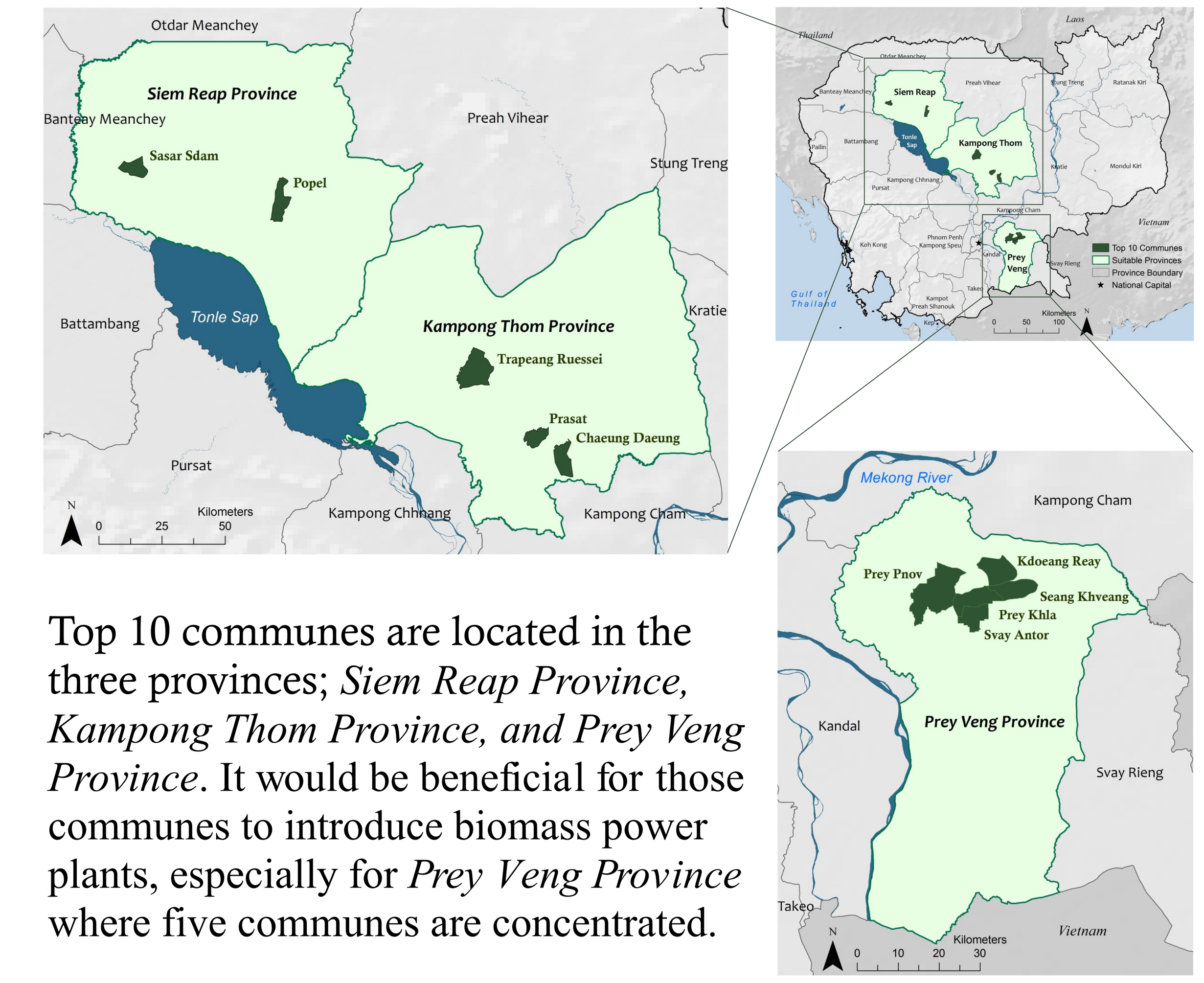
Top 10 Communes



Top 10 communes are located in the three provinces; *Siem Reap Province, Kampong Thom Province, and Prey Veng Province*. It would be beneficial for those communes to introduce biomass power plants, especially for *Prey Veng Province* where five communes are concentrated.

Top 10 Communes with Highest Suitability and Largest Impact

	Commune Name	Each Factor Score: Electricity Need	Each Factor Score: Biomass Potential	Each Factor Score: Physical Condition	Total Suitability Score	Population 2008 (>8,264)
	Chong Ampil	7.0	10.0	12.59	29.59	7,551
	Trapeang Thum	6.5	10.0	12.43	28.93	8,126
	Cheung Prey	7.0	10.0	11.66	28.66	7,335
1	**Prey Khla**	**6.5**	**9.0**	**12.79**	**28.29**	**8,468**
	Trapeang Bei	6.0	10.0	12.21	28.21	5,860
	Krang Sbov	6.0	10.0	12.07	28.07	4,983
	Sokh Sant	6.0	10.0	11.87	27.87	2,381
	Chres	6.5	10.0	11.35	27.85	7,179
2	**Svay Antor**	**4.6**	**10.0**	**13.22**	**27.82**	**9,374**
	Nhaeng Nhang	6.5	10.0	11.07	27.57	5,631
3	**Kdoeang Reay**	**6.2**	**9.0**	**12.29**	**27.49**	**9,856**
4	**Seang Khveang**	**7.0**	**9.0**	**11.27**	**27.27**	**8,402**
	Doun Koeng	6.5	9.0	11.72	27.22	6,773
	Chea Khlang	7.0	7.0	13.20	27.20	7,394
5	**Trapeang Ruessei**	**8.0**	**9.0**	**10.11**	**27.11**	**16,409**
6	**Prey Pnov**	**7.0**	**9.0**	**11.10**	**27.10**	**15,725**
7	**Prasat**	**7.0**	**8.0**	**11.98**	**26.98**	**9,194**
	Lvea	6.5	8.0	12.48	26.98	6,566
	Doun Yay	6.0	9.0	11.94	26.94	5,514
	Trabaek	7.0	8.0	11.82	26.82	4,927
	Sranal	7.5	9.0	10.30	26.80	8,166
	Chroab	8.0	8.0	10.78	26.78	4,300
	Sedthei	6.5	9.0	11.24	26.74	6,751
	Preaek Sambuor	7.5	10.0	9.22	26.72	4,091
	Tramaeng	6.0	9.0	11.64	26.64	5,950
8	**Chaeung Daeung**	**6.5**	**9.0**	**11.03**	**26.53**	**10,456**
	Sraeung	6.5	10.0	10.02	26.52	4,966
	Angkanh	6.0	10.0	10.49	26.49	5,385
	Chak	6.0	9.0	11.49	26.49	2,856
	Kaoh Pang	6.0	10.0	10.47	26.47	747
9	**Popel**	**6.5**	**8.0**	**11.95**	**26.45**	**10,260**
	Kampun	6.5	10.0	9.95	26.45	3,136
10	**Sasar Sdam**	**6.5**	**8.0**	**11.93**	**26.43**	**11,493**