

Refugee and IDP Camp Population Estimate Tool Derived from Automated Feature Extraction

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Agenda

- ▶ Introduction
 - ▶ Problem and Proposed Solution
 - ▶ Background
 - ▶ Study Area
- ▶ Objective
- ▶ Project Workflow
- ▶ Expected Outcome
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Problem and Proposed Solution

▶ Problem

- ▶ Effective management of refugee and internally displaced persons (IDP) camps rely on accurate, up-to-date, and comprehensive population estimates.^[1]
- ▶ Reliable population figures are often not available due to: ^[2]
 - ▶ Limited access to camp locations
 - ▶ Biased data for political purpose
 - ▶ Difficult nature of collecting data during large influxes of persons
- ▶ Traditional field-base estimates are time and resource intensive

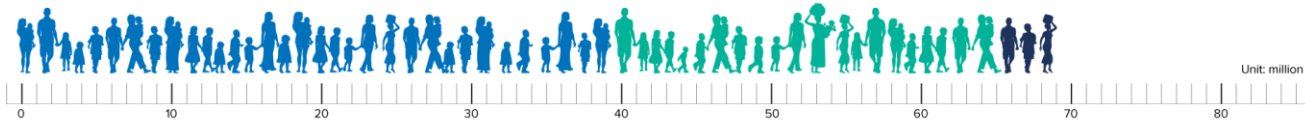
▶ Proposed Solution

- ▶ Develop a tool that calculates population estimates based on the area of camp dwellings derived from automated feature extraction

Refugee and IDP Worldwide Statistics

68.5 million forcibly displaced people worldwide

[3]



Internally Displaced People
40 million

Refugees
25.4 million

19.9 million under UNHCR mandate
5.4 million Palestinian refugees registered by UNRWA

Asylum-seekers
3.1 million

Where the world's displaced people are being hosted

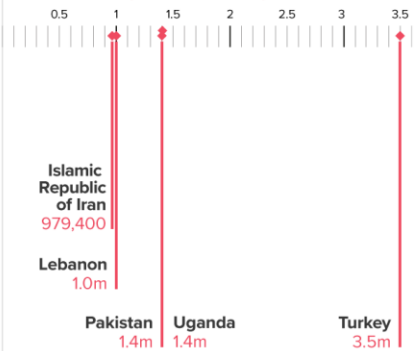


85 per cent of the world's displaced people are in developing countries

57% of refugees worldwide came from three countries



Top refugee-hosting countries



10 million stateless people



102,800 Refugees resettled

44,400 people

a day forced to flee their homes because of conflict and persecution

16,765 personnel

UNHCR employs 16,765 people worldwide (as of 30 November 2018)

138 countries

We work in 138 countries (as of 30 November 2018)

We are funded almost entirely by voluntary contributions, with 87 per cent from governments and the European Union and 10 per cent from private donors

Field-base Population Estimates

- ▶ Traditional method for population estimates
 - ▶ Camp registration
 - ▶ Camp census
- ▶ Benefits
 - ▶ Better ground truth
 - ▶ Ability to determine dwelling occupancy rates
- ▶ Challenges
 - ▶ Time and resource intensive
 - ▶ Bias
 - ▶ Safety concerns



Field-base camp interview. Source: [4]

Image-base Population Estimates

- ▶ Extract camp dwellings from high-resolution imagery
 - ▶ Manual feature extraction
 - ▶ Automated feature extraction
- ▶ Multiple dwelling figures and occupancy estimates [5]
 - ▶ (Number of Dwellings) x (Estimated persons per dwelling)
 - ▶ (Total dwelling area) x (Estimated persons per covered area)

Image-base Population Estimates [6,7,8,9,10]

▶ Benefits

- ▶ Less time and resource intensive
- ▶ Significantly decrease safety concerns
- ▶ Reasonable precision

▶ Limitations

- ▶ Requires highly-trained analysts
- ▶ Requires high-resolution imagery
- ▶ Inability to differentiate building function or occupancy status
- ▶ Relies on accurate field-based estimates
- ▶ Precision decreases in complex situations

Image-base Population Estimates

- ▶ Growing trend within the refugee and IDP humanitarian relief missions
 - ▶ Highlighted in *Camp Management Toolkit* ^[11]
 - ▶ United Nations High Commissioner for Human Rights (UNHCR) and International Organization for Migration (IOM) are already utilizing imagery to monitor refugee and IDP camps ^[12]
 - ▶ Somalia's Afgooye corridor
 - ▶ 2010 Haiti Earthquake

Manual vs. Automated Extraction [6,7,8,9,10]

▶ Manual feature extraction

▶ Benefits

- ▶ Human controlled extraction

▶ Limitations

- ▶ Time consuming
- ▶ Requires highly trained analysts
- ▶ Subjectivity leads to inconsistencies in complex situations
- ▶ Can not automate

▶ Automated feature extraction

▶ Benefits

- ▶ Scalable
- ▶ Transferable
- ▶ More consistent
- ▶ Ability to automate

▶ Limitations

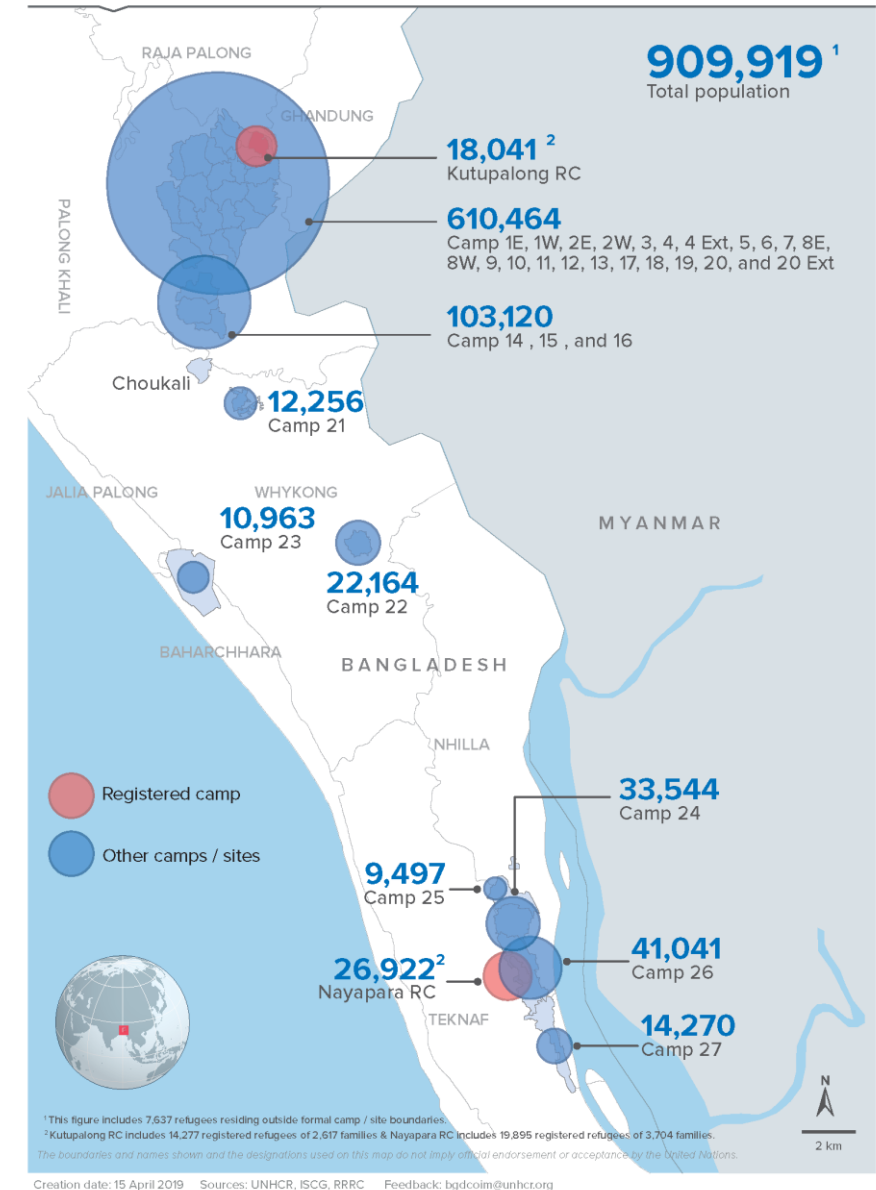
- ▶ Requires highly trained analysts to develop signature file
- ▶ Decrease accuracy in complex situations
- ▶ Spectral variance between sensors
- ▶ Geographical, seasonal, and material effects on spectral signatures

Object-base vs. Pixel-base

- ▶ Object-base: Classifies groups of pixels (objects) based on spectral, textual, and spatial properties
- ▶ Pixel-base: Classifies pixels independent from one another

Study Area

- ▶ Rohingya Refugee Emergency, Bangladesh [13]
 - ▶ Approximately 671,000 Rohingya refugees fled targeted violence in Myanmar since August 2017
 - ▶ Refugees settled in and around existing refugee camps in two areas, Kutupalong and Nayapara
 - ▶ More than 50,000 shelters have been erected. Building materials consist mainly of bamboo, rope, and tarpaulins
 - ▶ Population estimates are well documented



Objective

Develop a tool
to calculate refugee and IDP camp population estimates
based on dwelling figures
derived from automated feature extraction

Project Workflow

- ▶ Data acquisition
- ▶ Identify optimal automated feature extraction method
- ▶ Develop the tool
- ▶ Test and refine the tool
- ▶ Create a standard operating procedure document for the tool

Data Acquisition

► Imagery

Camp 1E
 Upazila: Ukhiya I Union: Palong Khali
 Settlement and Protection Profiling Round 3

General Infrastructure Map

■ Camp in charge office
■ Children friendly space
■ Temporary learning space

■ Health facility
■ Safe space for women and girls

The boundaries and names used on this map do not imply official endorsement or acceptance by the United Nations.

UNHCR

The UN Refugee Agency

REACH


Informing more effective humanitarian action

Requirement	IOM Drone Imagery	Digital Globe WV-3 -4
High-resolution	10cm	30cm
Multi-band	RGB	RGB and SWIR
Orthorectified	Yes	Yes
Regular collection	Every 3 months	At least 6x a year
Low to no-cost	Free	\$22.50 per sqkm
Accessible to HADR orgs	Yes	Yes

Source: [15]

Data Acquisition

► Camp population estimates


Camp 1E
Upazila: Ukhia | Union: Palong Khali
Settlement and Protection Profiling Round 3

Key Camp Information

Camp management:
UNHCR / BRAC

Population:
39,724 individuals¹
9,139 families²

Shelters:
4,928

Camp area:
0.47 km²

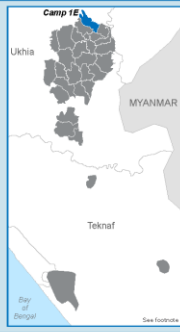
Population density:
70,709 individuals / km²

Average covered area per person: 3.69 m²

Average camp area per person: 14.1 m²

Shelter density:
10,575 shelters / km²

GPS coordinates:
21.18276, 92.15575



Demographics¹

Age and gender breakdown

♂ 49% male | 51% female ♀

4%	> 59	4%
40%	18 - 59	45%
14%	12 - 17	13%
23%	5 - 11	21%
15%	1 - 4	14%
4%	< 1	3%

- 53% of individuals are under 18.
- 79% of individuals are women and children.

Period of arrival
82% of families reported arriving 25 August 2017 or later.

Family size
Number of individuals per family:

37%	39%	22%	3%
1-3	4-5	6-8	>8

Individuals per family

- There is an average of 4.3 individuals per family.

Food Security

Food assistance

- 95% of families reported accessing food assistance in the last month, of these the common reported sources were:²

WFP	98%
Bangladeshi Army	8%

Consumption-based coping strategies
Top three most common consumption-based coping strategies:³

Borrow food	77%
Eat less preferred food	21%
Reduce number of meals	2%

Infant nutrition

- 35% of families reported receiving a supplementary feeding ration for children under 5.
- 2% of families reported receiving a breast-milk substitute (BMS) donation.

¹ Data provided by the RRRC-UNHCR Family Counting exercise.
² The boundaries and names used on this map do not imply official endorsement or acceptance by the United Nations.
³ Respondents could select multiple items from a list.
⁴ Self-reported and not verified through medical records.

Protection

Protection, safety and security

Top ten most commonly reported protection and safety concerns:²

Natural disasters	38%	Crime	21%
Animal attack	35%	Movement restrictions	10%
Human trafficking	24%	Site problems	8%
None	24%	Harassment	4%
Children getting lost	22%	GBV	4%

Top ten most commonly reported interventions needed:²

Warning systems	38%	Locks	16%
More police / military	29%	Permission to move freely	12%
Legal assistance	25%	Do not know	12%
Site improvement	17%	Transparency governance	7%
Nothing	17%	Support to PWSN	5%

People with specific needs (PWSN)
Proportion of individuals with specific needs:⁴

Single mother	12%	Child-headed family	3%
Persons with disability	6%	Separated children	2%
Medical condition	5%	Single father	1%
Elderly at risk	5%	Unaccompanied child	1%
Elderly with child	4%		

Requirements	UNHCR and RRRC Reports [15]
High confidence level	95% confidence level with 10% margin of error
Regular reporting	Biweekly
Information on average persons per covered area	Yes

Automated Feature Extraction Workflow

- ▶ Software - ArcMap 10.5.1
- ▶ **Object-based Extraction Workflow**
 - ▶ Segment image
 - ▶ Extract training areas (Table 1)
 - ▶ Use training areas to train the MLC, RT, and SVM classifiers
 - ▶ Output - Classifier Definition File
 - ▶ Classify image
 - ▶ Conduct accuracy assessment
- ▶ **Pixel-based Extraction Workflow**
 - ▶ Extract training areas (Table 1)
 - ▶ Use training areas to train the MLC, RT, and SVM classifiers
 - ▶ Output - Classifier Definition File
 - ▶ Classify image
 - ▶ Conduct accuracy assessment

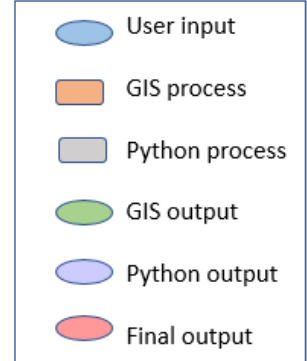
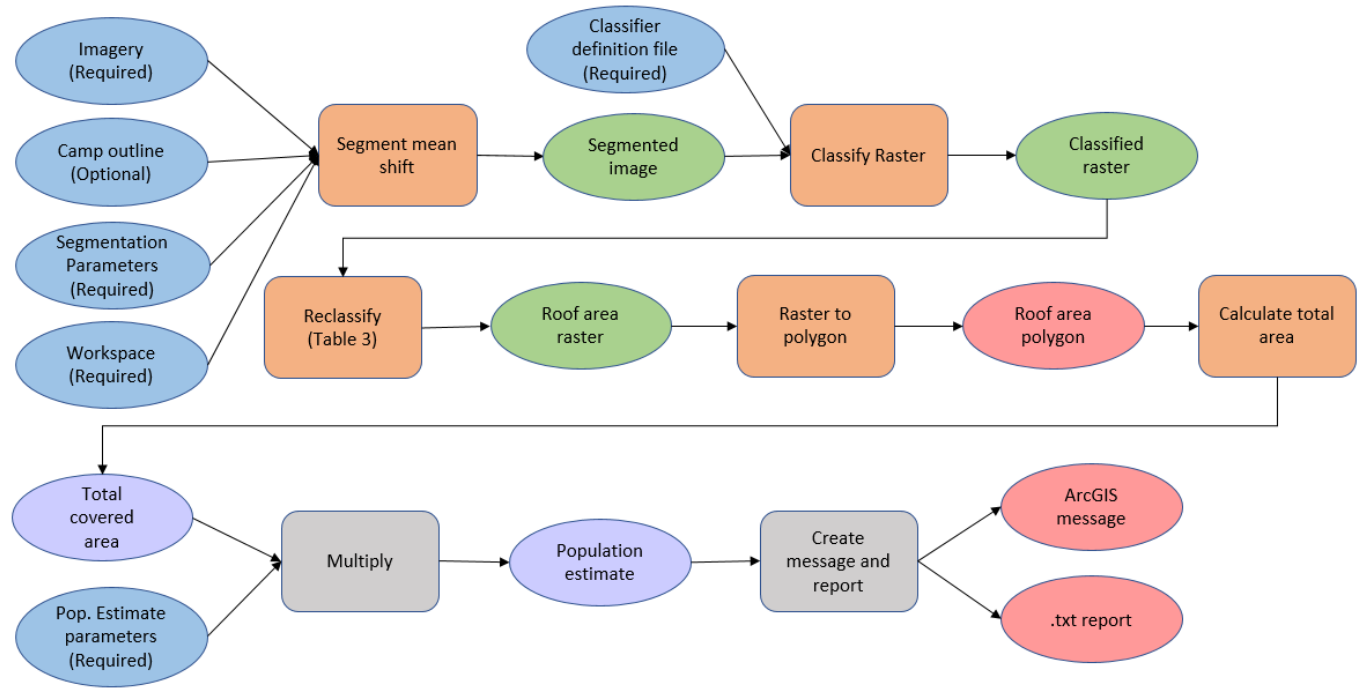
Table 1. Training Classes

1. Light-tone roof
2. Orange roof
3. Green roof
4. Brown roof
5. Blue roof
6. Dark-tone roof
7. Yellow roof
8. Water
9. Mud / dirt
10. Agriculture / grass
11. Trees

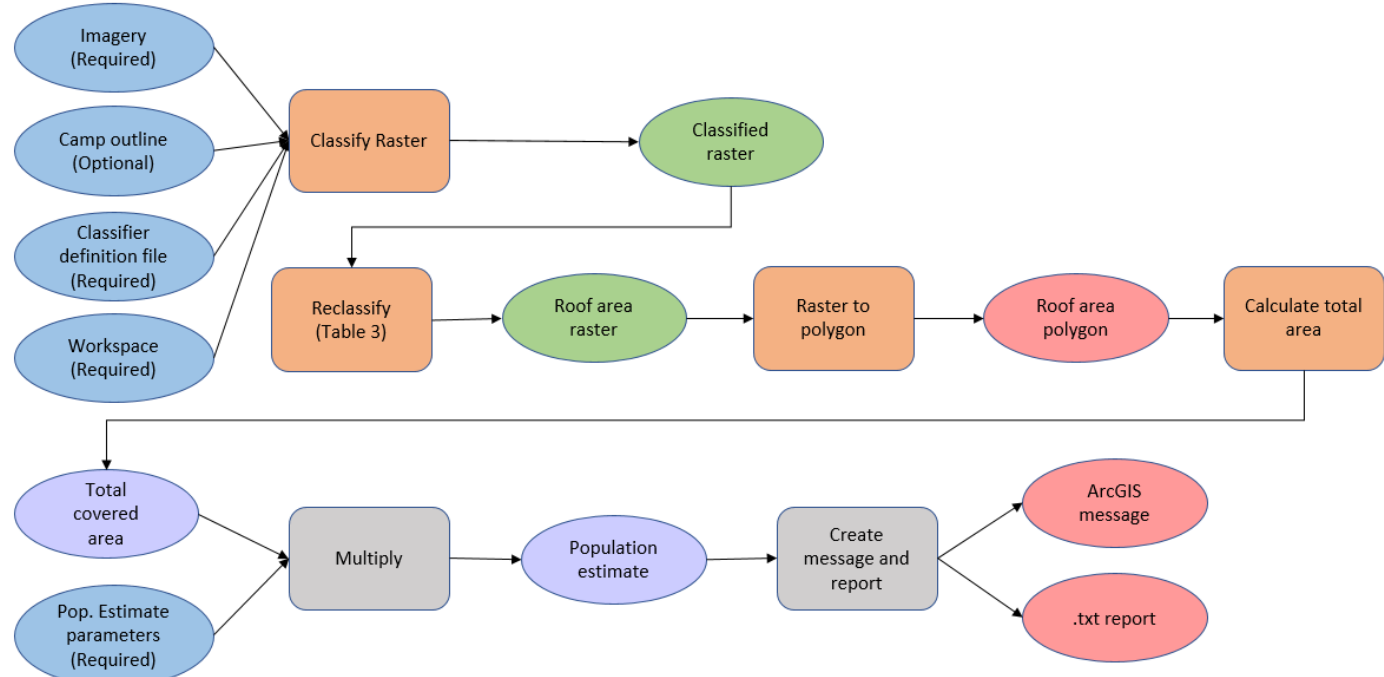
Camp Population Estimate Tool Parameters

Tool parameter	Requirement	Note
Image file	Required	Image source must correlate with classifier signature file.
Camp outline	Optional	Used to create a raster mask to decrease processing time and focus calculation area.
Segmentation parameters	Required	Used if an object-based approach is used. Default parameters will be provided.
Classifier definition file	Required	Classifier signature file must correlation with image source. Signature file from this study will be provided with the tool.
Population estimate parameters	Required	Based on average covered area per person.
Workspace	Required	Geodatabase

Object-Based Method Tool Workflow



Pixel-Based Method Tool Workflow



Validating the method and estimates

Compare classification methods and parameter combinations

Overall, user, and producer accuracies | Processing time | Consistency

► Validate image extraction method

Calculate average classification accuracies

	Test Area	Test Image Date
Test 1	Same area used to develop CDF	Same image date used to develop CDF
Test 2	Same area used to develop CDF	Different image date used to develop CDF
Test 3	Different area used to develop CDF	Same image date used to develop CDF
Test 4	Different area used to develop CDF	Different image date used to develop CDF

► Validate population estimates

Calculate population estimates based on dwelling figures derived from automated feature extraction

- At least a 75% overall classification accuracy
- Population estimate within a 15% margin of error compared to field-based estimates

Compare population estimates

Project Timeline

Deliverables

Task	Projected Completion Date
Literature review	Continuous
Collect data sources	Completed
Complete project proposal and peer review	2 May 2019
Compare automated methods	May 2019
Develop tool	May 2019
Test and refine tool	June 2019
Write tool standard operating procedure	June 2019
Deliver tool to potential customers	June 2019
Collect customer feedback	July 2019
Refine tool if necessary	July 2019
Complete comprehensive report	August 2019
Present at conference	TBD

Possible Presentation Venues

Name	Location	Dates
GIS in the Rockies	Denver, CO	September 17-18, 2019
Hawaii Geographic Information Coordinating Council Annual Meeting	Hawaii	TBD
Hawaii International Conference on System Science	Wailea, HI	January 7-10, 2020
ESRI Federal User Conference	Washington, DC	Winter 2020
All Partners Access Network, USINDOPACOM HADR Community Workshop	Honolulu, HI	Winter 2020
American Association of Geographers Annual Meeting	Denver, CO	April 6-20, 2020
University Consortium for GIS	Honolulu, HI	June 2020
Esri Speaker Series	Redlands, CA	Flexible dates

Question?

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Backup Slides

Identify Optimal Automated Feature Extraction Method

- ▶ Conduct multiple classifications using different method, classifier, and parameter combinations
 - ▶ Object-base vs. Pixel-base
 - ▶ Maximum Likelihood (MLC) vs. Random Trees (RT) vs. Support Vector Machine (SVM)
 - ▶ Segment attributes
- ▶ Compare classification methods and parameter combinations
 - ▶ Overall, user, and producer accuracies
 - ▶ Consistent results for different camps and dates
 - ▶ Processing time

Challenges and Limitations

▶ Data

- ▶ Multi-spectral high-resolution imagery costs
- ▶ Multiple image collections
- ▶ Accurate population estimates

▶ Automated feature extraction challenges and limitations

- ▶ Inability to differentiate building function and occupancy status
- ▶ Decreased accuracy in complex situations
 - ▶ Tree cover
 - ▶ Connected features
 - ▶ Multi-story dwellings
- ▶ Spectral variance between sensors
- ▶ Geographical, seasonal, and building material effects on spectral signatures

Deliverables

- ▶ Custom tool
 - ▶ ArcMap Toolbox
 - ▶ Python script
- ▶ Classifier Definition File
- ▶ Tool standard operation procedure document
- ▶ Tool accuracy assessment
 - ▶ Error matrix
 - ▶ Overall, user, and producer accuracies
 - ▶ Dwelling shapefile and map product
 - ▶ Comparison to field data
- ▶ Comprehensive report