Food and Agriculture Organization of the United Nations

المركز الوطني لتنمية الغطاء النباتي ومكافحة التصحر
National Center for Vegetation Cover Development & Combating Desertification

Al Baha Pilot NFI

Summary of Data Collection and Analysis Methodology

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Content

1. Introduction

The methodology employed for the Al Baha Pilot is documented in the inventory field manual prepared by the team based on standard FAO National Forest Inventory (NFI) methods. To achieve this, several meetings were held at the start of the process with FAO HQ NFI team under the leadership of David Morales.

FAO NFI documentation includes standard definitions of terms and elaboration of NFI procedures necessary to plan and execute success national forest inventories and assessments. These follow the approach developed by the Forest Resources Assessment (FRA) program. The methodology and procedures have been tested, adapted, and implemented in many countries all over the world.

Refer to the field manual (Annex 1) for more information on the sampling design adopted, the distribution and configuration of individual sample unit, and the range of measurements carried out within the sample unit. The field manual further describes the assessments carried out during field data collection and the protocols used for data collection by the field crews. Additionally, the field manual provides the details of the field data collection forms.

Before the start of the field data collection, the field crews were trained on data collection based on the field data collection forms. A digital version of the field data collection forms was developed, and field data collection crew trained on their use as part of the training program. Although it was initially planned to use both paper and digital forms at the start of the data collection exercise, the digital version proved more efficient, and use of paper forms was discontinued.

2. Sampling design

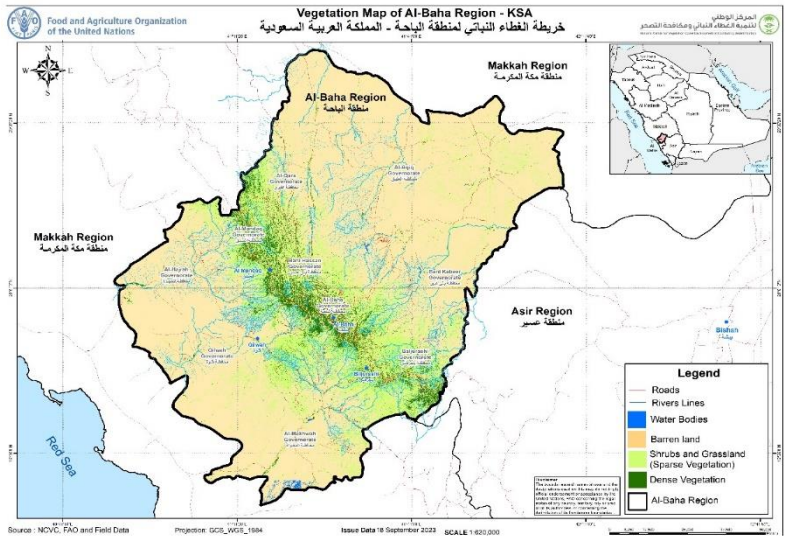
2.1 Importance of sampling design

Design and implementation of an appropriate sampling design is critical in an NFI process. The sample design that is put in place during the forest inventory, together with data collection procedures have a crucial role in controlling the accuracy and the quality of data obtained from the field and the information generated. It determines the quality and representativeness of the data collected, the value that can be obtained from the resulting outputs, as well as the kind of decision that can be made from the data and information generated.

2.2 Stratification approach

National Forest Inventory for KSA made good efforts to put in place suitable forest inventory sampling design that would fit the unique conditions of KSA, and the kind of forest data and information required in the Kingdom. Following a series of technical meetings, including with FAO HQ NFI team, it was agreed to use stratified systematic sampling with reasonable sampling intensities with respective stratums according to the potential of vegetation they possess.

Different maps and dataset have been used to create not-overlapping strata in the GIS environment. As KSA does not have a national land cover database and maps, vegetation map for Al Baha (Figure 1) was prepared and used as the base map. The vegetation map was prepared by the FAO geospatial unit using available information and validated through ground truthing. In addition to the vegetation map, rainfall, ecological zonation, and topography were used as additional inputs. These layers of data were used for stratification in a GIS environment (layers overlays) to identify different strata. It is important to note that in some cases, ground truthing was not possible due to the steep slopes. In these cases, Google Earth was used as a means of verification. Overall, four strata clearly were identified as shown in the map below.

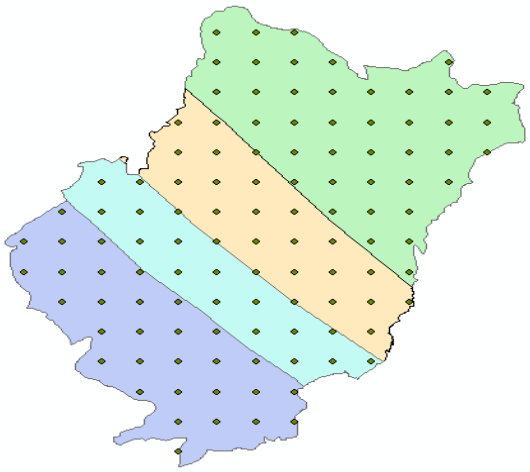


Get paragraph from Sanya on the approached used to compile the map and validate it.

Figure 1: Vegetation map of Al Baha

2.3 Systematic stratified sampling and intensification

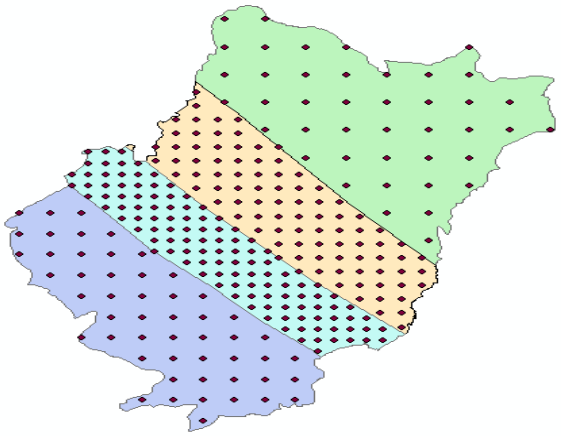
In this section, we examine how the setup for the systematic stratified sampling design and sampling intensity were determined for the Al Baha pilot NFI. At the entry point, the sampling allocation was carried out in GIS environment, with the objective of achieving 1% sampling intensity within each stratum as shown in Figure 2 below.



Strata (No)	Samples (No)	Area (unit)	Strata Area (%)	Distance between Sample (km)
1	41	393,760	35.3	10X10
2	24	236,373	21.2	10X10
3	17	184,475	16.5	10X10
4	31	300,995	27.0	10X10
Total	113	1,115,603	100	

Figure 2: Entry point sampling frame targeting 1 percent within strata and areas coverage

Based on the known fact that some areas of Al Baha had higher vegetation and forest cover, the team recommended increasing the sampling intensity in those areas to improve the sampling framework. Accordingly, a differentiated sampling intensity was implemented in the different strata (based on the distance between sample plots) as follows: 1.03% for stratum1, 4.07% for stratum 2, 7.98% for stratum 3, and 4.02% for stratum4. This resulted in the sampling intensity shown in Figure 3 below.



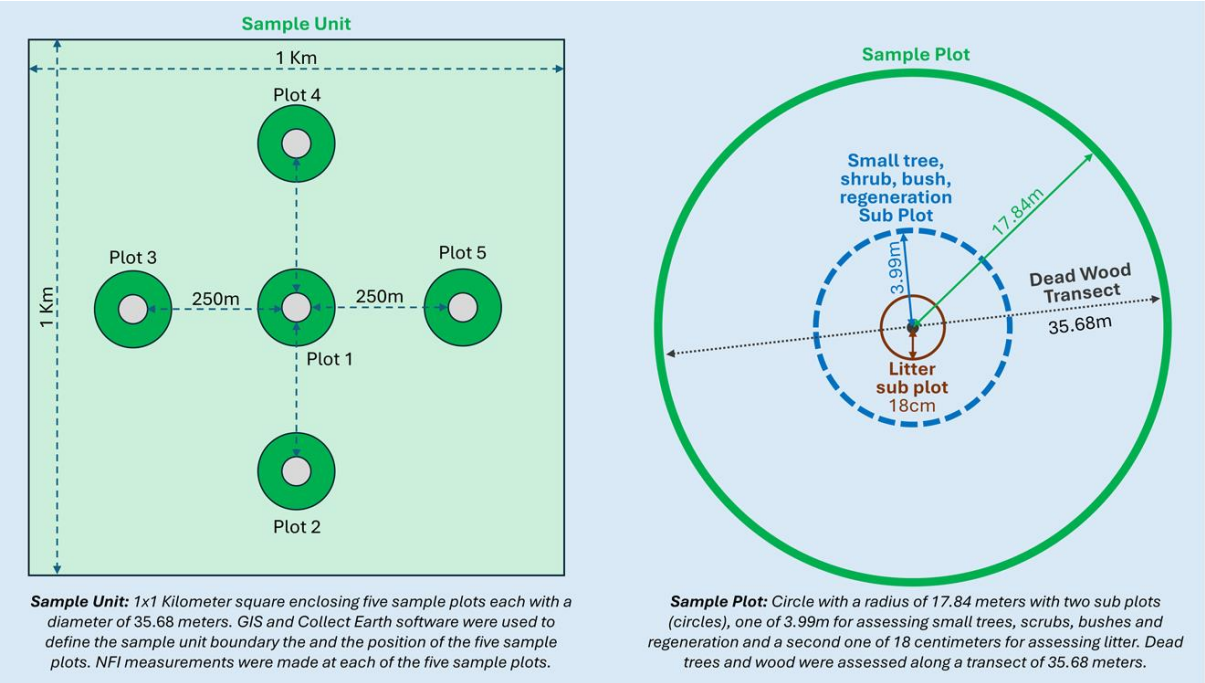
Strata (No)	Samples (No)	Area (Unit)	Strata Area (%)	Distance between Sample
1	42	393,760	35.3	10X10
2	92	236,373	21.2	5X5
3	117	184,475	16.5	4X4
4	52	300,995	27.0	7.5X7.5
Total	303	1,115,603	100	
			Sampling standard error	9.97
			Standard deviation	31.53

Figure 3: Sampling frame with high intensity in strata 2 and 3 where forest and vegetation cover is higher.

2.4 Sampling unit

The sample unit design adopted is shown in Figure 4 below. It consisted of 1 square kilometre (1km x 1km) with 5 sampling plots spread 250 meters apart. GIS and Collect Earth software were used to define the sample unit boundary the and the position of the five sample plots. NFI measurements were made at each of the five sample plots.

Each sampling plot had a radius of 17.84 meters and with two sub plots inside, one with a radius of 3.99 for assessing small trees, shrubs, bushes, and regenerations; and the other with a radius of 18cm for assessing litter.



Sample Unit: *1x1 Kilometer square enclosing five sample plots each with a diameter of 35.68 meters. GIS and Collect Earth software were used to define the sample unit boundary the and the position of the five sample plots. NFI measurements were made at each of the five sample plots.*

Sample Plot: *Circle with a radius of 17.84 meters with two sub plots (circles), one of 3.99m for assessing small trees, scrubs, bushes and regeneration and a second one of 18 centimeters for assessing litter. Dead trees and wood were assessed along a transect of 35.68 meters.*

Figure 4: Layout of the sample unit and sample plot

Before starting the field data collection, a rapid desk assessment was undertaken using FAO Collect Earth software (Figure 5 below) for all sample units to identify and exclude all sample units located in bare land and inaccessible area. This process was also used to collect information on major land use classes in the region.

Table 1 below summarizes the details of the sampling unit as implemented for the Al Baha pilot NFI.

Table 1: Sample unit measurement entities and their sizes

Unit	Shape	Size (area)	Number
Sampling Unit: Unit for NFI measurement	Square	1000 m x 1000 m (1km^2)	1 SU
Sample plot: Measure trees with Dbh ≥ 5cm	Circular	Radius = 17.84 m (1000 m^2)	5 per SU
Sub plot 1: Count trees with Dbh < 10cm and Shrubs, bushes, and regeneration	Circular	Radius = 3.99 m (50 m^2)	1 per plot
Sub plot 2: Assess litter depth and composition	Circular	Radius = 18 cm (0.1 m^2)	1 per plot
Fallen Dead wood Transect: Measure fallen deadwood branches (diameter ≥ 2.5 cm)	Line	Length = 35.68m	1 per plot

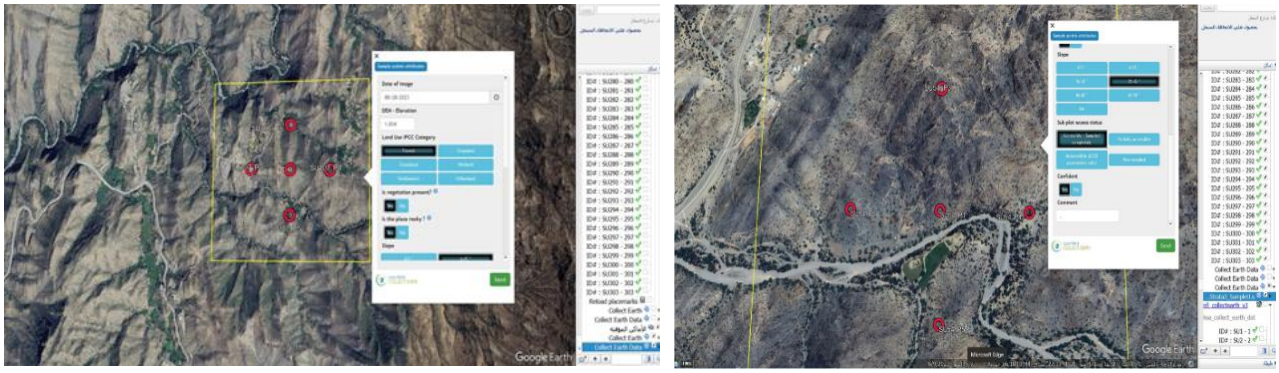


Figure 5: Rapid assessment with Collect Earth to identify base and inaccessible areas

3. Data processing and analysis

3.1 Data collection

Detailed description of the data collection methods and tools used for the Al Baha Pilot NFI are described in the field manual (See Annex 1). In preparation for the field data collection, FAO team prepared and delivered series of training courses to introduce the data collection methods and tools to the data collection team. The training courses were based on the field manual.

3.2 Data management

The pilot NFI data management, including conversion and migration to different formats was facilitated using the FAO Open Foris platform, including the Foris Collect Mobile software. All the data for the pilot NFI was collected using this tool and later exported from the individual devices for cleansing, processing and analysis. Foris Collect Mobile has features that ensure data is exported accurately from the devices used by the different field crews. The data exported is then imported into Collect Desktop for aggregation, cleaning, validation, and pre-processing before analysis. The aggregated data was then shared with the NFI team for analysis. Figure 6 below provides an overview of the overall data management process.

Figure 6: Pilot NFI data management process

3.3 Data analysis

After data cleaning, Open Foris Saiku, SAS JMP Package, and Microsoft Excel were used to estimate the basic statistics such as Averages, Sums, and Variances for Governorate level statistics. For this, the default factors and equations used by KSA to report to FRA and other global initiatives were used. Area estimates presented in this report are calculated based on Al Baha governorate areas shown on Table 2 below.

Table 2: Governorate land areas (km2) used in the analysis

Al-Aqiq	4014.6	Al-Mandaq	232.4	Ghamed Zenad	620.6
Al-Baha	284.3	Al-Qara	1052.3	Qilwah	1349.3
Al-Hajrah	877.9	Baljurashi	1407.2		
Al-Makhwah	1170.7	Bani Hassan	146.7		

3.4 Tree counts

Stems per hectare or tree counts are reported based on count of the DBH (Diameter at Breast Height) measurements taken within the clusters (sample unit) plots. DBH measurements of trees were recorded in three plots within the cluster (sample unit). The total stems per plot were then used along with the area of the plot to calculate the number of trees per hectare at the plot level; this information was then calculated for the strata and governorate. The area of each cluster was 1km^2 or 100 ha. The rea of sample plot (sub plot) was calculated with the area of circle formula (A$= \pi r^2$).

3.5 Basal area

Basal area is calculated based on DBH (Diameter at Breast Height) which was measured at 1.3 m above the ground over bark using a Caliper to obtain diameter. In the present inventory, basal area is reported in square meters per hectare (m^2/ha). The basal area estimation begins at the tree level and is then up scaled to the plot using a similar method to the tree count approach above. The basal area equation used in this inventory is BA = (DBH)^2 x π /4000, where BA = Basal Area, DBH = Diameter at Breast Height, and π = 3.14

3.6 Volume

The volume estimates reported in the inventory are based on per tree estimates using the equation Vol = BA x H x FF, where Vol = Vollum (m^3), H = Height of trees (m), FF = Form Factor of tree. Form Factor (FF) value of 0.65 is used as a default value for KSA based on KSA FRA report of 2015.

3.7 Biomass and carbon stock

Above Ground Biomass

The Above Ground Biomass was calculated using the equation ABG = VOL x WD x BEF, where ABG = Above Ground Biomas, WD = Wood Density, and BEF = Biomass Expansion Factor. Default values of 0.6 and 2 were used for WD and BEF respectively based on values reported by KSA for the FRA in 2015.

Below ground biomass

Below Ground Biomass was calculated using the equation BGB = AGB x V where AGB = Above Ground Biomass, BGB = Below Ground Biomass, and V = Vegetation specific Root:Shoot ratio. A value of 0.28 was used for V based on KSA FRA report for 2015.

Total tree biomass

The total tree biomass was then calculated as the sum of AGB and BGB.

Carbon stock

Carbon stock was calculated using the equation C = 0.47 x B, where C = Carbon Stock and B = Biomass. The default factor of 0.47 was used according to 2006 IPCC guidelines.

Several statistics were computers using the statistics equations given below.

Standard error	$s_d = \sqrt{v(\bar{x}_d)}$
Relative standard error	$relative\ \ s_d = \frac{100 * s_d}{\bar{x}_d}$
Sampling error	$SE_d = t * s_d$
Relative sampling error	$relative\ SE_d = \frac{100 * SE_d}{\bar{x}_d}$

Note: (i) t = Student's t-value at 0.05 probability level; Student's t-value: n = number of clusters in domain d.

Annex 1: Al Baha Pilot NFI field manual

(to attach)