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"THE INTEGRATED FOREST ECOSYSTEM MANAGEMENT PROJECT IN THE KYRGYZ REPUBLIC"
(IFEMP)

CONSULTING SERVICES

NATIONAL FOREST INVENTORY EXECUTION AND CAPACITY BUILDING

Contract № KG/IFEMP/QCBS/NFI/01/2018

TECHNICAL GUIDELINE FOR DATA QUALITY ASSURANCE
Task 3.3 Quality Assurance Protocol

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forestry and land use

NATIONAL FOREST INVENTORY EXECUTION AND CAPACITY BUILDING

Contract № KG/IFEMP/QCBS/NFI/01/2018

Technical Guideline for the data quality assurance
Task 3.3 Quality Assurance Protocol

Client
State Agency for Environmental Protection and Forestry

Authors
UNIQUE & CAREC

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DBH	Diameter of a tree stem measured at breast height (1.3 m)
DFED	Department of Forest Ecosystem Development
FMP	Forest Management Planning
GIS	Geographic Information System
IFEMP	Integrated Forest Ecosystem Management Project
NFI	National Forest Inventory
NFI #1	1st National Forest Inventory of the Kyrgyz Republic
NFI #2	2nd National Forest Inventory of the Kyrgyz Republic
SAEPF	State Agency for Environmental Protection and Forestry
SIKFHIP	State Institution "Kyrgyz Forest and Hunting Inventory and Planning"
TTFI	Technical Team for Forest Inventory
QA	Quality assurance
QC	Quality control
SFE	State Forest Enterprise (Leskhoz)

1 OBJECTIVES

This document refers to the ToR and the task description for Objective 03: Execute the NFI #2 field survey, where the following activities and outcomes are defined:

- **Activities:** 3-3-1: Define quality assurance protocols that maximize transparency and control over the field data collection process.
- **Outcome:** Quality assurance procedure produced

The quality assurance (QA) procedure accompanies all steps of the NFI #2 field work, data delivery and data acceptance. Continuous supervision and control of field work is important to ensure data quality of the field assessments and measurements. This includes data quality assurance during processing and analysis. The objective of the QA procedure for the NFI #2 is to guarantee a high level of data quality and to optimize the standards of a nationwide field methodology. A standardized QA protocol maximizes transparency and allows to identify and correct any occurring shortcoming on data quality during the field data collection process.

2 OVERALL APPROACH FOR QUALITY ASSURANCE (QA)

Errors that occur during field work are extremely difficult to identify and eliminate once the data have been delivered to the database. The most critical errors are systematic errors that can have a substantial impact on the results. Their avoidance has the highest priority for the QA. Continuous supervision and control of the field work by experienced control teams combined with systematic checking of the delivered data has the potential to minimize and correct systematic errors.

The QA procedure for the NFI #2 is composed of a 2-level approach to maximize the overall quality of data.

Field level

On the level of field data collection, intensive supervision of the field teams and close Field Controls of the assessments will help identify errors of different types:

- Crude errors - the true errors where the instructions of the field manual are not followed and measurements are done wrongly;
- Reduce random or measurement errors - the residual variability that is present in all empirical studies;
- Identify and correct systematic errors.

The supervision and control of the field work will be guaranteed by the Supervision & Control Teams. Their tasks include:

- Training;
- Support of the field teams;
- Control measurements and reporting (chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**).

Data level

On data level, the data packages recorded in the field are systematically checked for plausibility and completeness during different phases of the procedures:

- During field work, a set of plausibility checks are linked with a set of attributes and these checks are implemented in the data entry software. The data recording software will directly inform the field staff if the entered value is inside the expected range. Additionally, descriptive values are entered from predefined lists, which eliminates the error factor of misspelling or attributing wrong values.
- Once the data are synchronized with the database, the analysis software offers a set of automatized reports which can identify the plots and tracts which are not complete or some attributes are not plausible.
- Systematic monitoring by the Data Team to check inconsistencies in the data.

These steps will lead to an error free standardized database that is fully in line with the field work manual and creates a solid base for further processing and data analysis.

Regular Data Quality and Performance Reports identify issues in need of improvement in the methodology and shortcomings in field work performances. The monthly Data Acceptance Protocols compile the results of the Data Checks and Field Controls and regulates the disbursement of payments based on the provided data quality.

3 WORK TEAMS

The QA protocol is executed by two work teams in close cooperation. For the NFI #2, the different work teams are comprised of joint staff of UNIQUE CAREC and TTFI /SAEPF. To maximize ongoing capacity development, a tandem approach allows an intensive knowledge transfer on the job. This way the permanent TTFI / SAEPF experts are trained by UNIQUE-CAREC:

- during field work with the processes of supervision and control
- In the office as part of data checking, processing and analyses.

3.1 Supervision & Control Teams

UNIQUE-CAREC forest experts and TTFI staff member form the Supervision & Control Teams. Beside 5 experts of CAREC, 2 experts from SIKFHIP and 1 expert from the Department of FED under SAEPF will be organized in 4 mixed Supervision & Control Teams. Each Supervision & Control Team is responsible for the supervision of 3 field teams and the quality control of the respective field teams and their data. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the key composition of the Supervision & Control Teams. There are 4 Supervision & Control Teams; this allows that not all time all teams must be in the field and that the Supervision & Control Teams have sufficient time to fulfil both the Supervision & Control Teams obligations

and their other obligations as well. The teams will always be "mixed", by one CAREC/UNIQUE team member on the one side and one team member from a national institution.

Table 1: Composition of Supervision & Control Teams

No.	Name	Institution	Position
1	Kuban Matraimov	CAREC	Coordinator
2	Alexander Gradel	UNIQUE	Coordinator
3	Emil Ibraev	CAREC	National forest expert
4	Keneshbek Usenov	CAREC	National forest expert
5	*To be nominated*	CAREC	National forest expert
6	Jenish Ashyrbekov	SIKFHIP	Supervisor & Controller
7	*To be nominated*	SIKFHIP	Supervisor & Controller
8	Aibek Baydaliev	Department of forest ecosystem development, SAEPF	Supervisor & Controller
9	*Rajapbaev Muslim*	Biological Institute, National academy of science	Supervisor & Controller

3.1.1 Supervision Tasks

Close contact to the respective team leaders allows for immediate support in case of technical, supply or other problems. The Supervision & Control Teams provide guidance, direct communication and support in case of logistic or other issues. In addition, the tasks related to the supervision of the field teams include:

- Preparation of training;
- Support the training held by UNIQUE experts and trainers (trained during field test);
- Provision of and support with work packages for field teams;
- Confirm data uploads (export from tablet to server);
- Monitor and follow-up on general data flow;
- Liaise with public administration and Leskhozes (SFEs).

3.1.2 Field Control Tasks

The Supervision & Control Teams are responsible for the implementation of the Data QA Procedure in the field. At least 11 tracts will be controlled per field team, resulting in a maximum of 132 tracts subject to Field Controls. Consequently, approx. 10% of the total number of tracts are controlled (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

The results of the Field Controls and the evaluation of the field work is documented in brief Field Control Protocols. The outcome of the evaluation per tract is of relevance for the extent of bonus payments and will indicate the necessity of re-measurement of problematic tracts. The Supervision & Control Teams communicates closely with the Data Team to monitor possible issues identified during the Field Controls and/or Data Checks and reporting.

3.2 Data Team

Beside the Supervision & Control Teams, which are focusing on the field work itself, a Data Team will be created and tasked with data preparation, data check, processing and analysis.

3.2.1 Structure of the Data Team

Preparing work packages, conducting plausibility controls and data control is of high importance for assuring quality of data and the respective results. Therefore, the Data Team will have the lead role in the data analysis and conduct the data analysis in close cooperation with local experts. The Data Team is responsible for:

- the preparation of work packages,
- the data processing and
- pre-analyses.

Table 2: The Data Team of UNIQUE-CAREC will have the lead role in the data control and analysis.

No	Organization	Name	Position
	Core team of UNIQUE-CAREC		
1	UNIQUE	Matthias Dees	Database expert
2	CAREC	Erik Jentaev	GIS expert
3	UNIQUE	Metodi Panev	Database and software expert
4	CAREC	To be determined	GIS / database
	Support team of SIKFHIP		
5	SIKFHIP, section of cartography and data base	Marta Barkybaeva	TTFI
6	SIKFHIP, section of cartography and data base	Tumara Abdrakhmanova	TTFI
7	SIKFHIP, section of cartography and data base	NN to be determined	
8	SIKFHIP, section of cartography and data base	NN to be determined	

The SIKFHIP experts supporting the Data Team, will be intensively trained on the job in all the tasks of the data team.

3.2.2 Data Team Tasks

The Data Team is responsible for processing of the delivered data and first analyses. By performing standardized Data Checks, uploaded data is checked for completeness and plausibility. Any observations made during the Data Checks and preliminary analyses that are related to data quality are reported in the Data Check Reports. These findings are communicated directly to the Supervision & Control Teams. The general tasks of the Data Team comprise:

- Preparation of work packages:
  - List of team specific tracts to be measured by strata and districts;
  - Preparation of digital field maps;
  - Preparation NFI #1 and FMP datasets and old paper forms;

- The defined workday's quota per stratum is also included in the work package.

- Data Checks on uploaded data packages (i.e. cross-validation of GPS tracks, recorded working times);
- Document data completeness and plausibility;
- Control labelling, archive and transfer of delivered bore-cores;
- Data processing and pre-analyses;
- Second instance of troubleshooting (after the supervision & control team) and support in case any issues arise during field work with the measurement equipment or data collection software.

Once data packages have been considered as complete and plausible, they are accepted, and a brief Data Check Protocol is issued. A summary of all data quality checks is included in the Quality and Performance Report issued every second week. The evaluation of the data quality by the Data Team is of relevance for the extent of payments.

4 FIELD WORK PROCEDURE

Regular Field Controls sensitize field teams about the importance of data quality by frequent feedback. During feedback, open questions concerning the methodology and measurements can be clarified and discussed. As a result, data quality and measurement procedures are controlled in the field and the methodology can potentially be improved by considering inputs from the field teams.

The Supervision & Control Teams carry out re-measurements either together with (hot checks) or without the field teams (cold checks). Hot checks allow an immediate evaluation and improvement of the field processes and the direct correction of records is possible. Hot checks and Cold checks for the NFI #2 are defined as follows:

Hot checks

- At least one member of the Supervision & Control Team is present on the plot during the measurement of the field team;
- The controller follows closely the measurement process of the field team;
- The controller re-measures some of the attributes. The measurements are compared and discussed;
- A minimum of 3 tracts per field team should be controlled as hot checks, resulting in a total of 36 hot checks;
- Hot checks are extremely important at the start of field work of all new field teams;
- The subject of the hot checks can a full tract or only part of the plots, e.g. 1 or 2 sample plots.

Cold checks

- The control team receives the original tract data from the Data Team (available on the tablet) and re-measures independently the tract or sample plot;
- The responsible field team is not present during the cold checks, but can be upon request;
- A minimum of 4 tracts per field team should be controlled as cold checks, resulting in a total of 48 cold checks;
- The subject of the cold checks can a full tract or a partial measurement (1 or 2 sample plots).

Cold and hot checks can be combined during Field Control trips to maximize time efficiency. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the distribution of hot and cold checks for the NFI #2 according to Supervision & Control Team.

Table 3: Distribution of Field Controls between hot and cold checks

No. of Supervision & Control Team	Supervised no. of Field Teams	No. of Tracts to Control		Total
		Hot Checks	Cold Checks	
1	3	21	12	33
2	3	21	12	33
3	3	21	12	33
4	3	21	12	33
Total	**12**	**84**	**48**	**132 (≙ 10%) ***
*additional controls are possible depending on the performance of field teams.				

The selection of tracts to be controlled (hot and cold checks) is based on the following criteria:

- equally balanced over all field teams;
- Covering all strata and regions;
- results of the Data Checks – showing increased inconsistencies on some teams;
- prompt control after result of Data Checks are received;
- randomly selected from all measured tracts subject to control;
- general logistics (access, etc.).

The work of all field teams will be equally subject to control (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The evaluation of the field work in combination with findings from the Data Checks can result in increased controls for specific field teams. The continuous Data Checks will indicate cases that require closer controlling.

4.1 Field Control Protocol

As a result of the controls, a brief Field Control Protocol is issued for each controlled tract and will be used as reference for the next check of the respective team. The Field Control Protocols are accompanied by a feedback to the field team regarding data quality and work performance. The consequences resulting from the controls depend on the overall evaluation of the field work by the control team (chapter 0).

Field Control Protocols based on hot checks will be signed by the leader of the controlled field team. For cold checks, the Field Control Protocol will be signed by the responsible two Supervision & Control Team members and the field team leader of the controlled team. In case of any disagreement on any issue between the field and the Supervision & Control Team, both parties can record there view in a specific section. In case of cold checks, the field team leader attests his acceptance or issues a request for clarification by any means of communication within one week after the results of the controls have been communicated (SMS, email, etc.).

5 DATA CHECK PROCEDURE

The Data Check procedure focuses on the inspection of uploaded field data packages (data entry) for plausibility and completeness and the reporting of the results. The available software allows to keep track of the status of incoming data packages and provides different tools for the data management.

At a first step, the overall completeness of the provided data package is validated and cross-checked with the respective work package. Subsequently, plausibility checks examine a range of relations present in the delivered data, i.e. overall time needed per plot, recorded and planned location of the field teams (visualized via GIS and map features of the software), general plausibility of inter-variable relationships. Consequently, checked data packages are stored according to the updated status (e.g. from “entry” to “checked” or “rejected”) along with all relevant information concerning the data check procedure (i.e. date, name of responsible Data Team member, data quality evaluation, justifications, etc.).

5.1 Data Check Protocol

For documentation and feedback, the Data Team issues a short and approved protocol. Data Check Protocol for each work package showing the result of the data check for each tract. These current status and result of the check are visible in the “data check dashboard” of the NFI#2 software. Once the data are checked, the data team will mark the tract as “complete” and promote it further for analysis. All members of the Supervision & Control Team and the Data Team will be able follow the number of tracts that are 1) checked and complete; 2) checked and need more clarification from the field teams, as this is recorded on the dashboard visible to all Supervision & Control Team and Data Team members.

Relevant findings of the data check procedure are reported back to the Supervision & Control Teams for evaluation in the field. Identified issues and general shortcomings in field work performances are published in regular Data Quality and Performance Reports (based on the data checks and of a check of timely completion of work and delivery of data).

6 GENERAL WORKFLOW

The QA procedure is based on a steady and smooth exchange of data and direct communication between all teams involved.

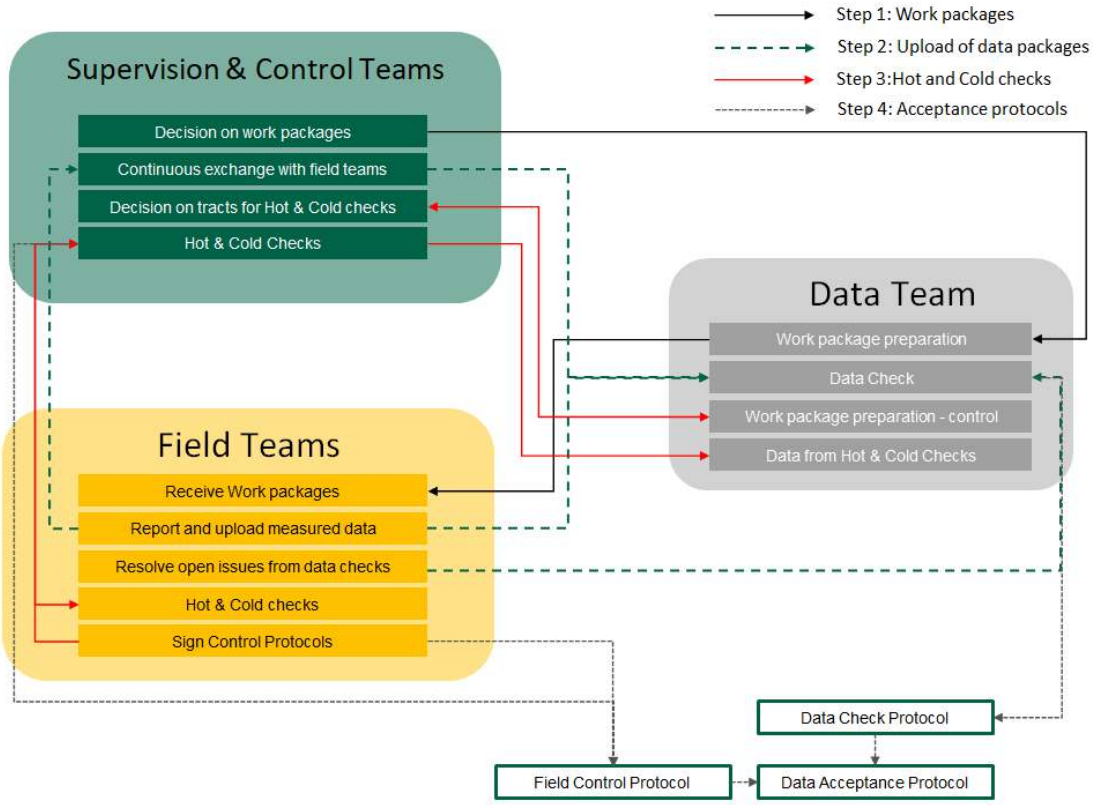

Figure 1 displays the work cycle and frequent communication between Field, Supervision & Control and Data Teams. The numbered work steps are explained below.

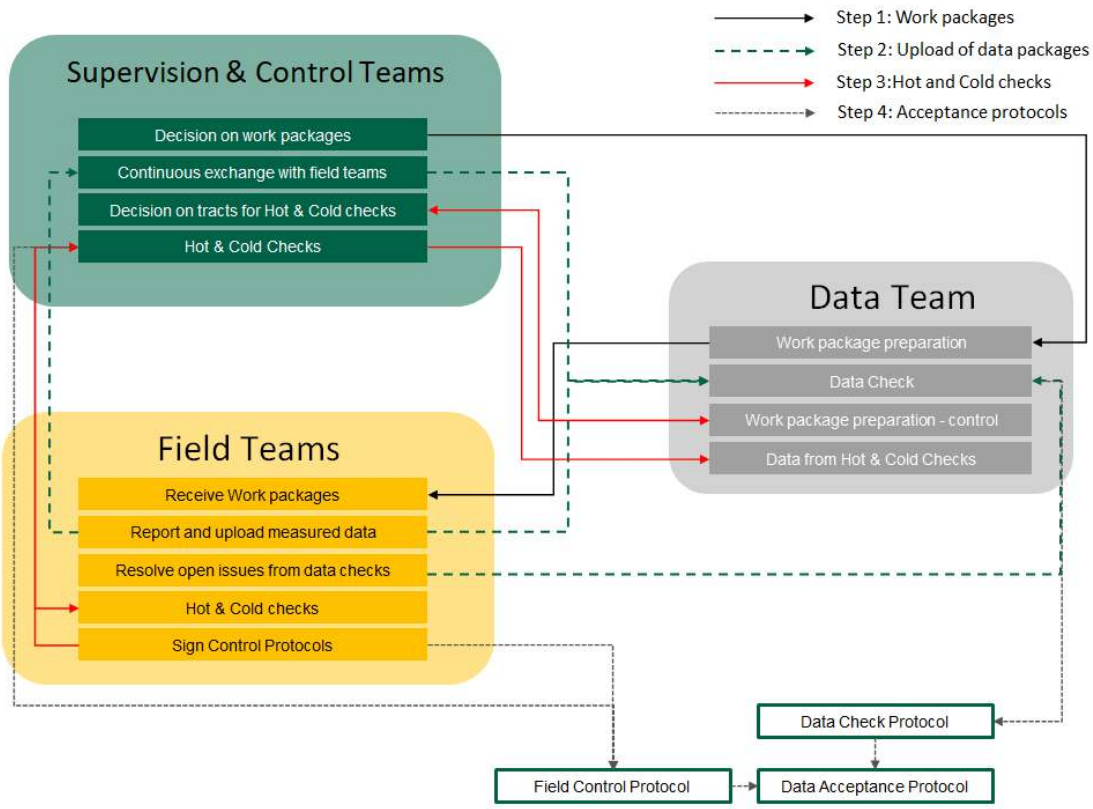

Figure 1: Work cycle and communication during the quality assurance procedure

Step 1 - Work Packages and Field Work

Work Packages are composed of:

- Digital datasets and templates for the tracts on which the specific teams are working
- Maps used for navigation:
  - Digital maps as part of the Data collecting app
  - Large scale overview maps where the region and the work area are presented
- A set of hard copy forms – as backup for the data recording, e.g. for the case when- for what ever reason - the data entry software is not working..

The Supervision & Control Teams decide on which tracts the teams are going to work in the period of 1-2 months. This decision is communicated to the Data Team, which issues the access to a set of tracts through the software. Once this step is done, the teams can synchronize their app and receive the access to the tracts on which they will work.

Separately from this, the Data Team will prepare a list with tracts by team, as overview and share this information with both the Supervision and Field Teams.

The digital maps will be preloaded in the tablets for the tracts in which the specific teams will work. If there is necessary to update the digital maps, the Supervision Team will have the role of linking the Data Team with the Field Teams.

During the field work, the field teams communicate with their supervisor regarding work plan, location, expected time of return and report any methodological, technical and logistic issues.

Step 2 - Upload of Data Packages and Data Check

Once the field teams have recorded the data from the field, they are uploaded as Data Packages to the central server. This activity should be done in the minimum once a week. The Field Team informs the Supervision & Control Teams and the data Team that they are finished with the tracts, and have uploaded the data to the server. The Supervision & Control Teams gather the information from all the field teams and give complete feedback to the Data Team.

Data stored in the database are visible for the Data Team and can be processed and checked for overall plausibility and completeness. Plausibility issues or incomplete data sets are reported back to the Field Team and Supervision & Control Teams. In case there are some inconsistencies that the Field Team can clarify, the changes are done directly in the Database by the Data Team.

The exchange of the photographic material captured by the field teams will be coordinated by the Supervision & Control Teams. This is necessary as photos are not automatically uploaded to the server. This material is stored locally on the tablets of the Field Team and will be transferred to the Data Team by a member of the Supervision & Control Team which are visiting regularly the Field Teams as part of the control activities.

Step 3 - Hot and Cold Checks

Field Controls commence shortly after the field data collection campaign has started and the first Data Packages are uploaded. In the beginning, hot checks will make up the major share of field controls. The evaluation of controlled tracts is documented in the Field Control Reports. During hot checks the Supervision & Control Team does not require a complete dataset for the measured tracts, all noticed inconsistencies with the measurements of the field teams will be corrected directly.

For the Cold Checks the Supervision & Control Team requires access to the original data gathered by the Field Teams. This procedure runs as follows:

- The Supervision & Control Team will select a set of tracts to be controlled;
- The Data Team will enable the access to the original data from the Field Team to the Supervision & Control Team;
- The Supervision & Control Team will download all the data to the tablet;
- Then the Supervision & Control team will conduct the control in form of a re-measurement of the selected tracts, simultaneously comparing their own measurements with the measurements of the respective Field Team of the respective tract; and providing and recording an evaluation of differences where needed.
- All data recorded in the field will be than sent back to the Data Team by direct synchronization with the Database;
- The Data Team has access to the original and the control data, and can analyze the differences between the two separate measurements;
- The information on differences and their evaluation is part of the Data Acceptance Protocols.

Step 4 Data Acceptance Protocols

The bi-monthly Data Acceptance Protocol is produced as a combination of Field Control Protocol, Data Check Protocols and relevant feedbacks from the field teams. The Data Acceptance Protocol regulates the work and performance related bonus payments based on the results of the Field Control and Data Check Protocols.

The general workflow over the duration of two months for one field team is displayed in Figure 2.

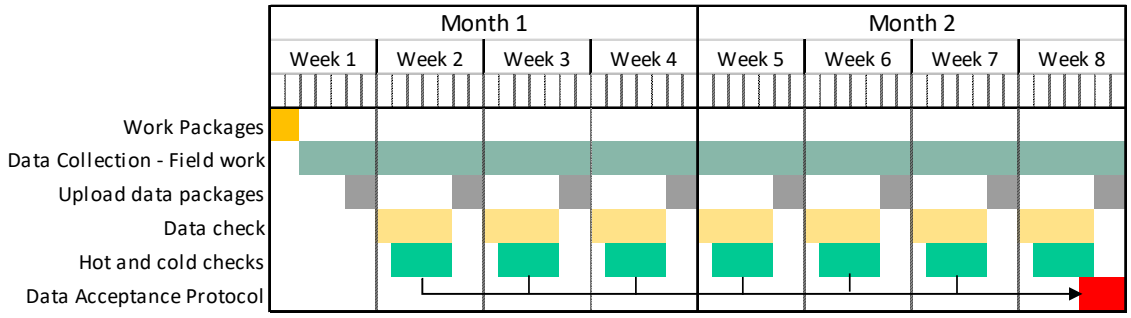

Figure 2: General workflow of the control and data check procedure

The results of the quality assurance procedure are documented in regular intervals in the following standardized reports:

- Field Control Protocol (per controlled tract that was selected for control)
- Data Check Protocol (per all delivered tracts; as every delivered tract is checked)
- Data Quality and Performance Report (bi-weekly, "Reporting", Figure 2, these are meant for a general monitoring of the projects progress)
- Data Acceptance and Enter Protocol (bi-monthly, only these are relevant for the teams payment)

7 DELIVERY ACCEPTANCE PROCEDURE

The result of the Data Quality Assurance Procedure for the NFI #2 is a systematic and standardized evaluation of the quality of the field data. The results of this evaluation determine if delivered data packages are accepted, and if bonus payments are disbursed according to the payment scheme. The bonus payment is only granted if the delivered data conform to the respective data quality standards. The data quality standards that field data must comply with are regulated in the delivery acceptance procedure. The decision on acceptance is based on the existence or absence of measurement errors as evaluated during the Field Controls and Data Checks. The delivery acceptance procedure combines the results of the evaluations of work performance quality (Field Controls) and data quality (Data Checks) and may claim the re-measurement of problematic tracts. The result of the data quality evaluation is documented in the Data Acceptance Protocol, which is issued for each field team once a month.

A frequent evaluation of the overall data quality based on the results of Data Quality Assurance Procedure is summarized in the Data Quality and Performance Reports that are issued every second week.

7.1 Identified Errors During Field Controls

During Field Controls, the overall number of errors per plot are recorded and identified errors are categorized according to error classes. Error classes can be either severe (intolerable) or errors of secondary relevance.

- **Intolerable errors** include those errors that influence the overall assessment (e.g. omitted trees).
- **Errors of secondary relevance** are obvious interpretation and/or estimation errors and other errors that are of minor impact on the results.

Whereas several errors of secondary relevance can be tolerable, the presence of intolerable errors leads to the rejection of the plot data. Table 4 shows an overview of potential error types and their evaluation during Field Controls, along with the respective consequences for data acceptance and the disbursement of performance bonuses.

Please note: The control of the age and increment cores is part of the data check procedure.

Table 4: Overview of Field Control error types, examples and related consequences

Error Type	Control	Examples	Error Classes	Evaluation Categories and Consequences
Location quality	Quality of GPS tracking and measurement + demarcation	Plot from NFI #1 or FMP not found although it would have obviously been possible	<u>Intolerable error:</u> Incl.: two obvious interpretation & estimation errors and other errors of secondary relevance	Excellent or good quality: no negative impact on performance bonus
Completeness	All objects on plot that are subject to assessments are measured	e.g. missed trees, regeneration plot not recorded, missed stumps or down deadwood, clear border not recorded		Inacceptable: reduction of performance bonus one extra hot control is mandatory
Quantitative attributes	Attribute recorded with correct values	e.g. Dbh, tree height, etc. Threshold approach to classify errors according to severity	<u>Errors of secondary relevance:</u>	Data from control

		Obvious serious systematic errors	obvious interpretation & estimation errors and other errors of secondary relevance	team is used
Descriptive attributes	Categorical and nominative attributes with correct class	e.g. undergrowth, damage, Kraft class, etc. Serious errors by expert evaluation		

For each variable, a specific error threshold is defined. The following Table 5 lists examples of errors with the respective tolerable error thresholds and the corresponding error class according to plot elements.

Tract and sample plot variables (5.1, 5.2)

Table 5: Field Control error classes and thresholds according to variable group

Intolerable errors	Errors of secondary relevance
Coordinates missing	Distance difference: > 5 m
No navigation to plot delivered (GPS tack)	Azimuth difference: > 10°
Control team cannot find the plot due to an error in GPS recording	Slope difference: > 15°
Reference Objects not marked with color	Exposition difference: > 30°
Reference points: ≥ 1 reference point is missing	Aspect not recorded although necessary
Clear borderlines not recorded	Coverage percentage error: > 30%

Regeneration (5.5)

Intolerable errors	Errors of secondary relevance
No regeneration assessed	Counting error > 30% of the count

Tree measurements (5.7)

Intolerable errors	Errors of secondary relevance
Number of missed trees: ±1 tree or more ≥ 15 cm DBH ±2 trees or more < 15 cm DBH	Difference of horizontal distance between tree and plot center > 50 cm
	For “close” trees, if distance to plot center: > 5.5 m and DBH > 15 cm, difference: > 25 cm > 11 m and DBH ≥ 15 m, difference: > 40 cm
	Difference of azimuth from plot center: > 5°
	Length of the marketable stem difference: > 2 m

Stumps (5.8)

Intolerable errors	Errors of secondary relevance
Number of missed stumps: ±2 stumps or more	Stump diameter difference: > 5 cm

Down dead wood (5.9)

Intolerable errors	Errors of secondary relevance
Number of missed down deadwood: ±2 pieces or more	Down dead wood diameter difference: > 10 cm
	Down dead wood length difference: > 1 m

General attributes with nominal and ordinal scale

Intolerable errors	Errors of secondary relevance

	Classification variables: obvious errors (e.g. micro relief, growth location, type of stump, conifer/broad-leaved mixture, etc.)
	Basic information variables: error when missing (e.g. tract type, tree number, forest and other wooded land, etc.)

As DBH and tree height measurements have a direct impact on the overall assessment (severe errors), the respective error thresholds are strictly defined. Table 6 shows the error thresholds for DBH and tree height measurements.

Table 6: Error thresholds for DBH and tree height measurements

DBH of Single Trees		
DBH	**Intolerable error**	**Errors of secondary relevance**
< 15 cm	> 20 mm	> 10 mm
15 - 60 cm	> 25 mm	> 12 mm
> 60 cm	> 30 mm	> 15 mm
Tree Height		
Conifers	> 20%	> 10%
Deciduous	> 25%	> 15%

An overview of all NFI #2 variables classified as attribute types relevant for the evaluation of the related error classes is provided in Table 15 and Table 16 in the Annex.

7.2 Identified Errors During Data Checks

During the Data Checks, errors can be identified regarding completeness and plausibility of the delivered data. The overall number of errors per plot are recorded and identified errors are categorized according to error classes. Table 7 shows a summary of potential error types and their evaluation during Data Checks, along with the respective consequences for the performance payment bonus.

Table 7: Overview of Data Check error types, examples and related consequences

<table>
<tr><th>Error Type</th><th>Control</th><th>Examples</th><th>Error Classes</th><th>Evaluation Categories and Consequences</th></tr>
<tr><td>Location quality</td><td>GPS tracks plausible, correspond to working packages and hours</td><td>Numbering of waypoints not in consecutive manner, GPS center coordinates not plausible, plot cut by a forest border line =1 (yes), but no border line measurement</td><td rowspan="3"><u>Intolerable error:</u>
Incl.: two obvious omittances of mandatory records and other plausibility or completeness issues

<u>Errors of secondary relevance:</u>
omittance of non-mandatory variables, minor plausibility issues</td><td>Excellent or good quality:
no negative impact on performance bonus</td></tr>
<tr><td>Completeness</td><td>All mandatory variables recorded; presence / absence of values is plausible</td><td>e.g. missed GPS coordinates or reference points or any other mandatory (i.e. azimuth, DBH, etc.) or descriptive variables (e.g. coverage with trees and shrubs) missing</td><td rowspan="3">Inacceptable:
reduction of performance bonus
one extra hot control envisaged depending on type of error

Data rejected</td></tr>
<tr><td>Quantitative attributes</td><td>Attribute recorded with plausible values; all mandatory values recorded</td><td>e.g. tract start time < tract end time, DBH < 8cm (6 m circle), DBH > 15cm (12 m circle)</td></tr>
<tr><td>Descriptive attributes</td><td>Combination of variables plausible (e.g. exposition and slope incline)</td><td>e.g. Kraft class and DBH and tree height, layer structure and assigned tree layers and vertical structure of the stand, etc.</td><td></td></tr>
</table>

Conspicuous records are reported to the Supervision & Control Team. Assigned error classes correspond to the error classes defined for Field Controls (cf. Ch. 7.1.). Incomplete data packages are those plot data where crucial key variables (e.g. GPS coordinates of the sample plot center) are missing. Errors that influence the overall assessment (e.g. omitted DBH measurements) are categorized as intolerable errors. Errors of secondary relevance are obvious omittances and/or implausible combinations of values that are of minor consequence (e.g. regeneration origin/vitality missing, combination of stump age and decay class not plausible). Table 8 shows the error classes assigned during Data Checks.

Table 8: Data Check error classes according to attribute group

Intolerable errors	Errors of secondary relevance
Tract and sample plot variables (5.1, 5.2)	
GPS coordinates of the sample plot center missing	Slope not recorded
No navigation to plot delivered (GPS tack)	Exposition not recorded
GPS track does not correspond to work package	Coverage percentage error missing
Reference points missing	Accessibility not recorded
Borderlines not recorded	
Regeneration (5.5)	
Regeneration assessed, but regeneration records missing	Origin and vitality not recorded
Tree measurements (5.7)	
Distance missing	Tree numbers not in consecutive order
Azimuth missing	Status of the tree on re-measured plots not consistent
DBH missing	Tree Kraft Class and DBH/Tree height not plausible
Number of measured tree heights insufficient	Tree layer and tree height not plausible
Stumps (5.8)	
Distance missing	Stump age and decay class not plausible
Azimuth missing	
Down dead wood (5.9)	
	Down dead wood length: < 1 m
General attributes with nominal and ordinal scale	
	Nominal variables: rounding or decimal errors
	Classification variables missing
	Basic information variables: error when missing (e.g. tract type, tree number, forest and other wooded land, etc.)

Table 9: Data check of bore cores

Intolerable errors	Errors of secondary relevance
No cores taken although required.	Age cores difference >20 years (for quality class “1”) Age and increment measurement quality assessed as class “2”, although rings are easily countable.
	Increment cores 10 years length: >1 cm (for quality class “1”) Increment measurement quality assessed as class “2”, although rings are easily countable.

7.3 Decision on Acceptance

Based on the overall count and classes of identified errors, delivered tract and plot data can be rejected. The detailed results of the Field Controls and Data Checks allows the evaluation of the data quality and determine the extent of bonus payments to be disbursed. Table 10 shows the evaluation of the field work performance and data quality based on the result of Field Controls and Data Checks.

Table 10: Evaluation categories for single plots based on Field Controls and Data Checks

Evaluation Category	Field Control Hot Checks	Field Control Cold Checks	Data Checks
Excellent	no observations made, very good knowledge of manual and procedures	no serious error, no observations made	data complete and values plausible
Good quality	observations in tolerable scope, good knowledge of manual and procedures	tolerable number of errors, observations in tolerable scope No intolerable errors, but up to three errors of secondary relevance	tolerable number of omittances, values generally plausible
Inacceptable	no improvement observed in comparison to previous hot controls, serious lack of knowledge of manual and procedures	number of errors too high, no learning vs. previous controls One intolerable error and/or more than three errors of secondary relevance	Intolerable omittances (error messages on missing data ignored), number of errors of secondary relevance too high

Consequently, delivered data packages and field control results will be classified according to error class and number of observed errors (Table 11).

Table 11: Consequences of evaluation of data quality per plot

Evaluation Category	Field Control Hot Checks	Field Control Cold Checks	Data Checks
Excellent	-	-	-
Good quality	Encouragement for improvement	Encouragement for improvement	Encouragement for improvement
Inacceptable	Replacement of teams	Bonus reduction (details see acceptance protocol , Ch. 7.4)	1. Re-measurement necessary 2. Bonus reduction (details see acceptance protocol , Ch. 7.4)

Standardized error monitoring allows to identify tendencies and re-occurring systematic errors over the entire field campaign. Intolerable errors are immediately communicated with the field teams and supervisors for sensibilization on the issue and attempting to retrieve the missing data, e.g. GPS coordinates of the sample plot center. If possible, errors of secondary relevance and omittances that are identified during Data Checks are directly corrected by the Data Team.

The Data Quality Assurance Procedure is composed of 2 quality assurance mechanisms. One on the level of field work (Field Controls) and one on the level of the data (Data Checks). The deci-

sion of acceptance can resort to a wide range of quantifiable criteria defined in both mechanisms. However, given the variability in present field conditions the severity of the same error (e.g. missed tree) must be evaluated in consideration of the site conditions under which the error occurred. Accordingly, data quality can be expected to be higher under favorable site and / or plot conditions. Hence, decisions about acceptance of data packages should take the following into account:

- the field conditions (e.g. slope terrain, etc.)
- the plot conditions (DBH-distributions, n/ ha, amount of dead wood, etc.)
- the different norm time consumptions per stratum
- the general overall performance of the field team (random mistake or re-occurring systematic errors?)
- frequency of similar errors observed for other field teams (methodological problem?)

A certain margin of tolerance allows for a case-by-case evaluation of the severity of data quality flaws and hence the consequences for the disbursement of bonus payments.

7.4 Data Acceptance Protocol

The Data Acceptance Protocol documents whether the delivered plot & tract data quality is accepted or rejected, and to which extend bonus payments are to be disbursed. The Data Acceptance Protocol is issued on a bi-monthly basis and includes the evaluation of all delivered tract & plot data of the previous two months.

The evaluation of the data quality considers the amount of errors defined during Data Checks, as well as the results of the Hot and Cold Checks, respectively. Per month, a regular work cycle of the Data Quality Assurance Procedure consists of 4 Data Checks and 1 Hot Check and 1 Cold Check for each field team. A point-based evaluation system regulates to which extend bonus payments are disbursed. The number of errors detected during Field Controls represent the mean number of errors per controlled plot. Table 12 shows the points to be gained according to the number of detected errors during Data Checks, Hot Controls and Cold Controls on plot level.

Table 12: Points awarded according to mean number of errors per plot

(Max value per plot =100 points)	Number of Minor Errors				Intolerable Errors
	0-1	**2-3**	**4-5**	**>5**	**>0**
Data Checks	100	80	50	0	0
Hot Checks	100	80	50	0	0
Cold Checks	100	80	50	0	0

Considering the number of plots measured in a two months work package the nominal total number of points (max. achievable points) are:

Maximum achievable points:

Data check points	Number of field plots *100
+ Hot check points	Number of hot checks * 100
+ Cold check points	Number of cold cecks * 100

For the bonus determination the quality percentage of achieved points out of the maximum achievable points is determined:

100 * Achieved points / maximum achievable points

The bonus is then determined using the achieved quality percentage in accordance with Table 13-

Table 13: Bonus payment as a result of the quality percentage – formula and examples

Quality percentage (QP)	**Bonus (100 – 3*[100-QP])**
100%	**100%**
90%	**70%**
80%	**40%**
60%	**0%**

Another aspect that is taken into account is the timely delivery of results. If in absence of any force majure (e.g. bad weather conditions), that need to be approved by the supervisor team, there is a delivery delay of more than a week the deductions shown in Table 14 are made.

In this context it is important to note that **per diems** are not payed for actual days but for nominal plan days; only in case of force majeure (e.g. bad weather conditions), that need to be approved by the Supervision & Control team additional days caused by force majeure are covered.

Table 14: Bonus payment reduction as a result of late data delivery

Late Data Delivery	**Additional reduction of Bonus Payment**
1-week delay (considering days of delay caused by force majeure only)	-25%
2-week delay (considering days of delay caused by force majeure only)	-50%

The Data Acceptance Protocol provides details on the data quality evaluation per tract based on Field Controls and Data Checks and the related extent of the bonus payment reduction.

The field teams are entitled to demand a joint re-visit of the tract if they are in doubt about the result of the control (the re-visit will not result in per diems or salary payment to the field teams).

8 ANNEX

Table 15: Overview of NFI #2 tract and plot level attributes (Field Manual Ch. no in brackets)

Tract	Plot level	Stand characteristics circle	Sample plot (12 m radius)	Sample plot (6 m radius)	Regeneration plot
Time recording and GPS measurement related attributes with references to the chapter they are defined in the field manual					
Recording of the navigation to the tract (5.1.4) Tract Start Time (5.1.5) Tract End Time (5.1.6) GPS Coordinates of the Sample Plot Center (5.2.4, 5.2.10.2)	Start Time of Measurements on the Sample Plot (5.2.11)				
Other tract and plot level measured attributes with references to the chapter they are defined in the field manual					
Reference points establishment (5.2.5)	Border line measurement (5.2.16)		Slope incline (5.2.18) Exposition (5.2.19)		
Other tract and plot level quantitative attributes with references to the chapter they are defined in the field manual					
		Estimation of percentages: Coverage with trees and shrubs (5.2.14) Crown coverage with trees and shrubs (5.3.5) Crown coverage with trees (5.3.6) Two dominating tree species (5.3.7)	Estimation of percentages: Coverage with shrubs (5.4.1) Single shrub species (5.4.2) Single shrub species coverage (5.4.3) Height of shrub species (5.4.4)	Estimation of percentages: Ground cover type & ground cover percentage (5.3.17) Litter depth (5.3.18)	Counting: Young forest species counting (5.5.3)
Nominal, ordinal scale and other tract and plot level variables with references to the chapter they are defined in the field manual					
Basic information: Field Team Leader (5.1.3) Classification variable: Accessibility of the sample plot (5.2.7)	Basic information: Re-finding of NFI #1 or FMP plot (5.2.8) Standard photographs of sample-plot (5.2.12) Classification variable: Forest and other wooded land (5.2.13)	Basic information: Age assessment method (5.3.10) Age (5.3.11) Classification variable: Forest and other wooded land (5.2.13) Terrain relief (5.2.20) Micro relief, terrain shape (5.2.21) Traces of erosion (5.2.22) Growth location (5.3.1) Conifer, broadleaved mixture (5.3.2) Origin (5.3.2) Forest type group, Forest formations (5.3.4) Forest types (5.3.8) Development stage (5.3.9) Walnut portion (5.3.12) Layer structure (5.3.13) Undergrowth (5.3.14) Disturbance/ Forces in the forest stand (5.3.15) Resistance of the forest stand (5.3.16)	Basic information: Plot cut by a border line (5.2.15) Classification variable: Grazing (5.3.19)		Classification variable: Nature of the young forest (5.5.1)

Table 16: Overview of NFI #2 tree, stump and down deadwood attributes (Field Manual Ch. no in brackets)

Tree attributes	**Stump attributes**	**Down dead wood attributes**
Measured tree/stump/down deadwood attributes		
Azimuth (5.7.5) Distance (5.7.6) DBH of single trees (5.7.9) Age core length (5.7.14) Age (5.7.15) Increment cores 10 years length (5.7.16) Length of the marketable stem (5.7.19)	Azimuth (5.7.5) Distance (5.7.6) Stump diameter (5.8.3)	Down Dead-Wood Diameter (5.9.1) Down Dead-Wood Length (5.9.2)
Nominal, ordinal scale and other tree/stump/down deadwood variables		
Basic information: Tree number NFI #2 (5.7.1) Tree number and DBH NFI #1 or previous FMP inventory (5.7.2) Classification variable: Identification of trees to be measures (5.7.3) Status of the tree on re-measures plots, trees living at NFI #1 (5.7.4) Tree status (5.7.7) Tree species identification (5.7.8) Layers, Vertical structure of the stand (5.7.10) Damage of the tree (5.7.11) Tree Kraft Class (5.7.12) Marketability - stem quality class (5.7.18) Burls (5.7.20) Decay Class (5.7.21)	Classification variable: Type of stump (5.8.2) Stump marking (5.8.6) Stump decay class (5.8.7) Stump age (5.8.5)	Classification variable: Down Dead-Wood Decay Class (5.9.3)