Advancing Skill Creation to ENhance Transformation

Training Handbook

Field Experiments & Observations

Work Package 5: Research Methods

Prepared by:

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Advancing Skill Creation to ENhance Transformation

ASCENT (Advancing Skill Creation to ENhance Transformation), is a project co-funded by an EU Erasmus+ programme grant. The project will run for three years and is led by the University of Huddersfield's Global Disaster Resilience Centre, based in the UK. They are joined by a consortium of 13 European and Asian higher education institutions from the Bangladesh, Estonia, Lithuania, Sri Lanka, Sweden, Thailand and the UK.

The project was inspired by the Sendai Framework for Action 2015-2030, signed by 187 UN member states in March 2015, as a 15-year, voluntary, non-binding agreement which recognises that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. The Framework identifies that international, regional, sub-regional and trans-boundary cooperation remains pivotal in supporting the efforts of States, their national and local authorities, as well as communities and businesses, to reduce disaster risk.

Over three years, the project will support training, skills, leadership development, international collaboration and university-industry partnerships. It will strengthen the ability of higher education to respond to research needs in disaster resilience. It will also empower individuals and organisations with the skills, competencies and credentials needed to continue to pursue research, and to lead research at institutions, aimed at reducing the impact of disasters.

Aim and Objectives

ASCENT aims to address R&I capacity strengthening for the development of societal resilience to disasters - supporting training, skills, leadership development, international collaboration and university-industry partnerships. It will strengthen the ability of partner HEIs to respond to their research needs in disaster resilience.

ASCENT will achieve this aim by: 1) identifying research and innovative capacity needs across partner country HEIs to tackle the development of societal resilience to disasters; 2) developing research infrastructure to support implementation of the project and provide sustainable capacity development within the partner HEIs ; 3) preparing researchers in the identified Asian countries to undertake advanced, world-class and innovative, multi- and inter-disciplinary research that will contribute to increased societal resilience to disasters; 4) Increasing international cooperation by partners HEIs on research programmes that tackle ways to increase societal resilience to disasters; 5) exploring, promoting and initiating opportunities for fruitful university / industry partnerships to increase societal resilience to disasters; and 6) publicising the project progress, successes and outcomes as far as possible, and raising awareness across the field of HE about capacity building for disaster resilience research.

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The consortium

Programme Countries (Europe)

- University of Huddersfield, United Kingdom (Lead Partner)
- University of Central Lancashire, United Kingdom
- Lund University, Sweden
- Mid-Sweden University, Sweden
- Vilnius Gediminas Technical University, Lithuania
- Tallinn University of Technology, Estonia

Partner Countries (Asia)

- University of Moratuwa, Sri Lanka
- University of Colombo, Sri Lanka
- University of Ruhuna, Sri Lanka
- Naresuan University, Thailand
- Chiang Mai University, Thailand
- University of Dhaka, Bangladesh
- BRAC University, Bangladesh
- Patuakhali Science and Technology University, Bangladesh

For further information on the ASCENT project, contact Professor Dilanthi Amaratunga (d.amaratunga@hud.ac.uk) and Professor Richard Haigh (r.haigh@hud.ac.uk) or visit the website at www.disaster-resilience.net/ascent.

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1 Session 5 – Field Experiments & Observations

1.1 Introduction

The present manual, describes the basic methods and techniques that are widely used in conducting field, protected house or laboratory experiments in Natural Sciences, Agriculture and forestry domains with special references to conduct experiments in Disaster resilience programs.

Currently disasters have been escalated in an exponential scale and communities have to live with rapid (Floods, Storms, Hurricanes, Tornadoes, etc.) as well as slow onset (Droughts) disasters. The climate and weather change patterns have impacted much on Agriculture ecosystems by changing seasonality, onset termination and duration of cropping seasons etc. Farmers have to deal with their agricultural activities under severe threats of often disasters to manage the Agro Ecosystems. In order to orient agricultural practices to meet the disasters, field experiments have to be mostly conducted under natural environmental settings with farmers and other communities. In the present session field experiments will be defined as a scientific method to experimentally examine an intervention in the real world (or as many experimentalists like to say, naturally occurring environments) rather than in the laboratory or artificial or built environment.

(https://en.wikipedia.org/wiki/Field_experiment).

When conducting field Experiment in experimental stations or farmer fields to test a hypothesis or introduce a new technology to build farmer resilience, one has to adhered to strict layout procedures and techniques to minimize the errors occurred due to heterogenic field conditions. The researcher should have a knowledge on specific design principles and the sources of experimental errors in terms of subjective as well as objective to control and or to minimize them . Furthermore, researchers should deal with strict data observation and recording procedures and interpret the observed data using relevant biometrical and statistical techniques to confirm the results scientifically and to make appropriate conclusions.

The training program incorporate a class room session, observation of simple experiment layouts in the field and in a protected house (control environment) with an objective to expose the trainees to understand and gain necessary skills in field experimentation by giving considerations to principles, methodologies, techniques and layout procedures in real world situations. The manual will assist the trainers to follow the step-by-step procedure of conducting a field and laboratory experiments and also to analyse and interpret data using appropriate statistical tools.

1.2 Training delivery mode

The basic training modules and their delivery mode are presented in the Table 1.

Field visits will consist of two field trials and one protected house trial.

The following topics are incorporated to the training module.

Table 1: Training topics

Module	**Mode of delivery**	**Duration**
Experimental design	Class room discussion	01hrs
Design types Demonstration • Completely Randomized design • Randomized Complete Block design • Split plot design	Field demonstration	O2hrs
Data analysis and interpretation	Group Activity and discussion	02hrs
Total		05 hrs

1.3 Duration of the session

Total duration of this Session will be 5 hrs.

1.4 Online training notes

N/A

1.5 Trainers

1.5.1 **Prof. K.D.N.Weerasinghe** (Professor Emeritus)

Engineer Agronomist holding Ph.D in Agriculture. Asoka fellow for community mobilization and social entrepreneurship. Served 34 years in the academic filed and also having vast experience in working with communities and interdisciplinary teams in many countries to build resilient agricultural practices to reduce multi-hazard impacts.
He has 80 journal publications and more than 150 Conference papers in the carrier as an Agronomist and Academic. Engaged with community restoration and resilience building programs in disaster resilience and response management, etc. under various donor supported projects funded by CIDA (Canada), German Corporation, NSF (US), World Bank AusAID, ViINNOVA, (Sweden), UNIDO (Vienna), etc. He has worked actively in indigenous technology development for the benefit of under-privileged and most vulnerable segments of communities such as rural farmer community by initiating and coordinating number of international and national projects with agencies such as Dept. of Minor Export crops, National Science Foundation, Cinnamon grower associations, Spice association of Sri Lanka etc. He also has International experience in France, UK, Pakistan, and India (ICRISAT) on Climate change research.

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1.5.2 Mrs. Nimalshanthi Gunaratne

A Senior lecturer attached to Department of Crop Science, University of Ruhuna who has been conducting lectures for undergraduates and postgraduates and conducting research on statistics since 1983. Further, she engages with statistical consultation for planning and designing research and data analysis. In addition, she has been engaging in the executive council of Institute of Applied statistics, Sri Lanka since 2007 at various capacities. She has supervised more than 70 undergraduates and more than 15 postgraduate students.

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1.5.3 Prof. (Mrs.) Champa Navaratne

A professor in Department of Agricultural Engineering having teaching and research experiences for more than 30 years in the fields of Agricultural Engineering. She has been a pioneer researcher in the fields of climate change, water management and disaster resilience and possess more than 75 research findings in journals and symposia proceedings as full articles and abstract forms.

She has organized and served as a resource person for more than 50 awareness and capacity building workshops in the fields of impacts of climate change and adaptation, impacts of unregulated river sand mining, drought and drought proofing, flood management and catchment conservation to build up disaster resilience.

Contact details:
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Department: Agricultural Engineering
University: University of Ruhuna
Country: Sri Lanka
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1.6 Contents of the Session

- Field Experiment Techniques
    - Definitions (Experiment, Experimental unit, Factor, Factor levels/treatment)
    - Plot size, shape and orientation
    - Replication, Randomization and Blocking
    - Experimental Designs (***CRD, RCBD, LSD, Split plot***, Split-split plot, Strip plot, Confounding designs, Fractional factorial designs, Incomplete Block designs)
    - Sampling, data collection, analysing and interpretation

1.7 Field Experiments and Observations

The objective of the present module is to build awareness and develop skills among the participants to design and conduct a field or lab experimentation to test a hypothesis. The presentation mode is given in the training booklet. The specific features of conducting an experiment in natural conditions will be the main focus of the program.

At the end of the program participants will be able to

Define and understand field and lab. Experiments

Understand specific nature of field experimentation procedures

Understand experimental layout procedures under different situations

Principles and methodologies adapting in error control

Field observation procedure

Statistical analysis and data Interpretation

1.7.1 Experiment vs. field experiment

An experiment is a procedure carried out to support, refute, or validate a hypothesis. Experiments provide insight into cause-and-effect by demonstrating what outcome occurs when a particular factor is manipulated. (https://en.wikipedia.org/wiki/Experiment**)**

A field experiment applies the scientific method to experimentally examine an intervention in the real world (or as many experimentalists like to say, naturally occurring environments) rather than in the laboratory. (https://en.wikipedia.org/wiki/Field_experiment**).**

Field experiments are conducted in the field plots (experimental units) and when selecting the field plots its size, shape and the orientations are important. It is the unit to which the treatment is randomly (unplanned) assigned.

1.7.2 Procedures to adapt in field experimentation

Definition of the problem (Research problem)

Statement of objectives

Selection of treatments

Selection of experimental material

Selection of experimental design

Selection of the unit for observation and the number of replications

Control of the effects of the adjacent units on each other

Consideration of data to be collected

Outlining statistical analysis and summarization of results

Analyzing data and interpreting results

Preparation of a complete, readable and correct document

When conducting an experiment under natural settings in nature the experimenter has to face number of difficulties links to the natural phenomena. For eg. When setting an experiment in agricultural fields, factors related to heterogeneity of the soils such as topographical differences of the land, soil moisture content or nutrient differences, microclimatic variations etc. are to be dealt with. Therefore, experimenter has to adapt specific procedures in conducting an experiment to eliminate errors which may be occurred due to various heterogeneity factors. There are different possibilities that could be adapted to conduct an experiment to test a hypothesis related to a natural environmental variables. Following options are available for the researcher to test these hypotheses. For eg. if a researcher wishes to test an impact of new fertilizer on performance of a rice plant, he may test it by conducting

Experiment in real field conditions.

Experiment in controlled environment (in lab conditions or protected house).

1.7.3. Field experiments in real field conditions

There are number of steps to be followed to overcome the heterogeneity of the environment when field experiments are conducted. Here experiments are to be conducted in selected field units which should be homogenous in nature. But as explained earlier it is practically impossible to find a homogenous situation in most of the cases. Therefore, specific field techniques are to be adapted in terms of selection of the plot size, shape and orientation, required number of replications (repetitions) blocking and randomization techniques etc. in designing phase of field experiments.

1.7.4 Key words and vocabulary

Let us focus our attention on techniques and related key words which are to be deeply understood when conducting a field experiment

Randomization

In order to eliminate any bias (subjective errors) and to ensure independence among observations randomization technique is used.

Replications

How often a complete set of treatments is repeated in an experiment is called a number of replications. Replications in an experiment are required to measure the experimental error.

1.7.5 Experimental Designs

The experimental design is the master plan specifying the methods and procedures for collecting and analyzing the needed information. It refers to the rules regulating the assignment of treatments to the experimental plots. The design helps to compare among treatments without any bias. It helps to control the principle source of variation in field experiments due to soil heterogeneity. Therefore, replication, randomization and error control are the key principles of a proper experimental design.

In the table 1 the brief understanding of the key elements used in experimentation procedures are given.

Table 2. Key elements in understanding of an experiment layout

Treatment	procedure whose effect will be measured
Factor	class of related treatments
Levels	states of a factor
Variable	measurable characteristic of a plot
Experimental unit (plot)	unit to which a treatment is applied
Replications	Experimental units that receive the same treatment
Sampling unit	part of experimental unit that is measured
Block	group of homogeneous experimental units
Experimental error	variation among experimental units that are treated alike

1.7.4 Types of Experimental Designs

When designing a field experiment, main focus should be primarily given to the

Magnitude of the soil heterogeneity on the experimental site

Direction of the soil heterogeneity in the field.

Number of treatments to be tested

The degree of desired accuracy

(It is always recommended to consult a statistician whenever necessary to use the most appropriate design to ensure that the objectives of the experiment are met).

The designs used in field experiments are (***Completely Randomized Designs, Randomized Complete Block Design, Latin Square Design, Split plot***, Split-split plot, Strip plot, Confounding designs, Fractional factorial design, Incomplete Block designs). Single factor experimental designs are used when the levels of only one factor to be tested while factorial experiments are used to test the combinations of the levels of more than one factor.

Completely Randomized Designs

A completely randomized design is probably the simplest experimental design to be practiced when the experimental units are homogeneous. The number of replicates is not restricted. However if number of treatments are increased (more than 10), it is susceptible to increase error factor.

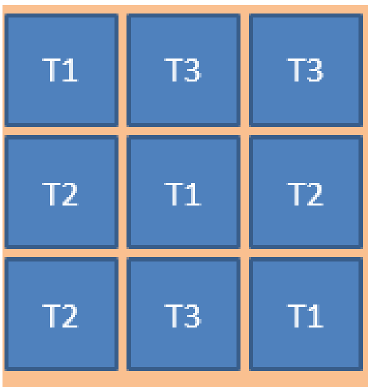

Figure 1: CRD Field Layout

Randomized Complete Block Design

When experimental units are not homogeneous, Blocks or groups are chosen in such a way that variability among experimental units within a block is kept as minimum as possible while the differences among blocks are maximized. Then all the treatments should be assigned randomly within the block and blocks are replicated.

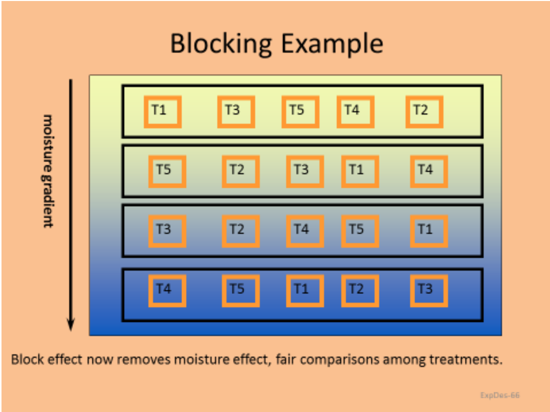

Figure 2: RCBD field layout

The Latin Square design

The Latin square design is used when there are two sources of variation existed among experimental units in addition to the treatment variation. Then blocking should be done to eliminate the effect of both sources from the experimental error. Blocks against to the direction of one source are called columns while blocks against to the other direction are called rows.

- Treatments are assigned at random within rows and columns, with each treatment once per row and once per column.
- Since the block has to be complete, the size of each row and each column should be equal to the number of treatments.

Sample layout:
Different letter represent different treatments. There are 4 treatments (A-D) assigned to 4 rows (I-IV) and 4 columns (1-4).

	Column			
Rows	C1	C2	C3	C3
R1	B	C	D	A
R2	C	D	A	B
R3	D	A	B	C
R4	A	B	C	D

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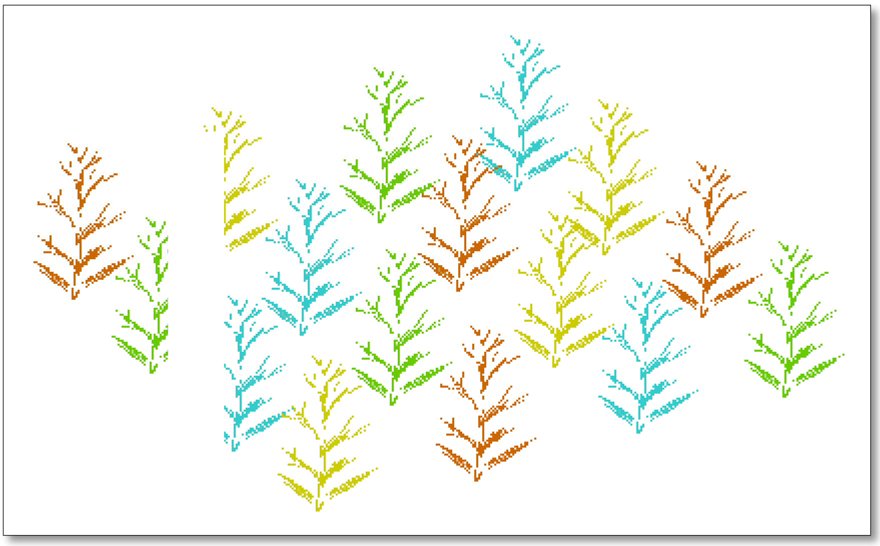

Fig.3: LSD field layout

Split plot design

When multi-factor experiments are conducted in different sites, split plot designs could be implemented. The levels of the first factor are applied to larger experimental units using randomization within the replicate. Following that, the levels of second Factor are applied to sub-units within the first factor. In other words, the experimental unit used for the application of the first factor will be split to form experimental units for the levels of the second factor. This method is widely used when conducted farming systems research with different farmers.

A1	A2	A3	A1	A4	A3
A3	A1	A2	A4	A2	A1
A4	A3	A1	A3	A1	A2
A2	A4	A4	A2	A3	A4

Figure 4: Field layout of Split plot design

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1.8 Demonstrational Experiments

Demonstrational experiments will be observed by the participants to clearly observe the following field Experimental methods

1. Split plot Design

Here Water use efficiency of "chili plants" as influenced by mulching and irrigation methods will be demonstrated. Objective of the experiment is to minimize water requirement of the crop using appropriate techniques such as mulching and pot irrigation. The crop used in the field is green Chili (*Capcicum annum)*.

The factor 1 of the experiment is mulching (with and without mulching) is assigned to the main plots while factor 2 – irrigation (pot irrigation and manual irrigation) is assigned to subplots with three replicates.

T1T3R1	T2T3R1	T1T4R2	T2T4R2	T2T3R3	T1T3R3
T1T4R1	T2T4R1	T1T3R2	T2T3R2	T2T4R3	T1T4R3

Figure 5: Demonstration field layout of Split plot Experiment

T1 – with mulch

T2 – without mulch

T3 – pot irrigation

T4 – manual irrigation

R1, R2, R3 – replicates

2. Randomized Complete Block Design

In the observation experiment 2, RCB Design is demonstrated to understand the design principles and field layout of RCB when experiment is conducted with rice. Here the feasibility of organic rice production in Mapalana when biogas slurry and bio fertilizer (Bio amino) are being used as fertilizers will be assessed with an objective to assess feasibility of biogas slurry and bio fertilizer to promote organic rice production.

Research plots are laid in a paddy field of the Faculty of agriculture, Mapalana, Kamburupitiya. Three types of fertilizers, Bio slurry, bio fertilizer (Bio amino) and chemical fertilizer (control) will be tested in Randomized complete block design with five replicates in the paddy field.

RCBD Field layout;

T1R1	T2R1	T3R1
T2R2	T3R2	T2R2
T1R3	T2R3	T3R3
T3R4	T1R4	T2R4
T2R5	T3R5	T1R5

Figure 6: Demonstration field layout of RCBD Experiment

T1 – Biogas slurry

T2 – Bio fertilizer (BioAmino)

T3 – Commercial Fertilizer (Chemical)

Participants will have an opportunity to observe the experiment and discuss the pros and cons of the split plot design

1.9 Data observation and analytical techniques

The specific aspects of the data observation and data interpretation techniques will be further demonstrated to arrive final conclusions of the research. The analytical features using stat Packages such as Minitab, and SAS will be also introduced.

2 ACTIVITY

1. Identify the differences between field and laboratory or green house experiments.

2. An experiment was conducted to study the yield performance of five tomato varieties grown in a green house. Each treatment was randomly assigned to experimental units (pot) while five times replicated.

Tomato Yield (Kg/plot) recorded from 25 pots

Variety	Yield				
1	1.6	1.9	1.5	2.1	1.7
2	1.9	2.4	2.3	2.2	2.1
3	2.3	2.6	2.4	2.5	2.7
4	1.2	0.8	1.0	0.9	0.8
5	2.6	2.8	3.0	2.9	2.8

i. Give the experiment layout for random allocation of treatments
ii. Analyze and interpret the results

3. To evaluate the Nitrogen fertilizer efficiency on coconut yield four levels of nitrogen as 0.5, 0.75, 1.0 and 1.25, kg/palm/year were tested using 24 coconut palms in six terraces. Four equally grown palms from each terrace were selected to assign those four treatments. Nut yield /palm/year was recorded.

Treatment N Kg/palm/year	Rep1	Rep2	Rep3	Rep4	Rep5	Rep6
N1	50	45	60	40	42	45
N2	70	60	80	40	50	60
N3	80	60	79	50	55	75
N4	110	100	120	90	85	100

i. Give the field layout

ii. Analyze and interpret the results.

4. An experiment was conducted to study the effects of a newly developed insecticidal spray on cotton stainer in a field with two directional soil gradients. Six different concentrations of the insecticide were applied and the yield kg /plot were recorded.

T1: I1 Control (no insecticides),
T2: I2
T3: I3
T4: I4
T5: I5
T6: I6

Row	Colum	Treatment	Yield
1	1	3	3.1
1	2	6	6.0
1	3	1	2.0
1	4	5	6.4
1	5	2	4.0
1	6	4	5.3
2	1	2	4.8
2	2	1	2.7
2	3	3	3.3
2	4	6	6.0
2	5	4	3.7
2	6	5	5.4
3	1	1	3
3	2	2	2.9
3	3	5	6.7
3	4	4	6.0
3	5	6	7.7
3	6	3	7.1
4	1	5	6.4
4	2	4	5.8
4	3	2	3.8
4	4	3	6.5
4	5	1	4.8
4	6	6	9.4
5	1	6	5.2
5	2	3	4.8
5	3	4	6.6
5	4	2	4.6

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5	5	5	7
5	6	1	5
6	1	4	4.2
6	2	5	6.6
6	3	6	9.3
6	4	1	4.9
6	5	3	9.3
6	6	2	8.4

i. Give the field layout
ii. Analyze the data and interpret the results

5. A field experiment was conducted to study the effect of mulch and N on maize yield. Two levels for mulch (with and without mulch) which need larger plots and three levels of N (0, 15 Kg/ha and 30 Kg/ha) were used in the experiment. The results were recorded as below.

The yield (Kg/plot) recorded from the experiment

Replicate	*M1N1*	*M1N2*	*M1N3*	*M2N1*	*M2N2*	*M2N3*
1	26.8	29.2	38.1	17.5	21.2	20.5
2	8.4	10.8	18.1	6.3	8.9	8.1
3	10.5	13.4	18.9	8.1	9.5	8.4

i. Draw the field layout
ii. Analyze and interpret the results

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