Agro-ecosystem Analysis

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management. Decision making in pest management requires a thorough analysis of the agroecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

Definition of AESA:

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyse field situations with regard to pests, defenders, soil conditions, plant health, the influence of climatic factors and their interrelationship for growing healthy crop. Such a critical analysis of the field situations will help in taking appropriate decision on management practices.

A. Why AESA is needed:
   i. It improves decision-making skills, through a field situation analysis by observing, drawing and discussing.
   ii. Improves decision-making skills by presenting small group decisions for critique in the large group.

The basic components Methodology of AESA are:

I. Field observation
   i. Enter the field at least 1.5 m away from the bund. Select a 1 m2 area at random.
   ii. Record visual observations in the following sequence:
      a. Flying insects (both pests & defenders)
b. Close observation of pests and defenders on plants.

c. Observe pests like borer and BPH and defenders like coccinellid, chrysopa, ground beetle/rove beetle and earwigs, by scraping the soil surface around the plants.

d. Record disease and its intensity.

e. Record insect damage and disease incidence as percentage.

iii. Record parameters like number of leaves, plant height and reproductive parts of selected plants for making observation in the ensuing weeks. Observe nematode damage symptoms.

iv. Record types of weeds, their size and population density in relation to crop plant.

iii. Record soil conditions, namely flooded, wet or dry.

iv. Observe rodent live burrows.

v. Record climatic factors, namely sunny, partially sunny, cloudy or rainy for the preceding week.

II. Drawing

Make a chart, with a drawing of the plant in its centre, pests on left side and defenders on the right side of the plant. Indicate the soil condition, weed population, rodent damage, among others. Use natural colours, for instance, green for a healthy plant and yellow for a diseased plant or leaves. Care should be taken to place the pests and defenders on the part of the plant where they were observed. The common name of the pest should be indicated on the diagram. Weather conditions should be depicted appropriately, for example by the figure of a sun just above the plant to indicate sunny conditions. Clouds indicate cloudy conditions while a sun half-masked by clouds, indicates partially sunny conditions.

III. Group discussion and decision-making

The observations depicted in the previous and current charts should be discussed by the farmers with questions related to changes in pest and defender populations in relation to crop stages and soil and weather conditions. The group may evolve a strategy based upon weekly AESA observation and corresponding changes in the pest-defender ratio (P:D) and decide on appropriate pest management practices.

IV. Strategy for decision-making

- Some defenders like lady bird beetles, ground beetles, rove beetles and wasps play an important role in determining the P:D ratio. Plant health at different stages
- Built-in compensation
- abilities of the plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Pest: Defender ratio (P:D ratio)
- Decision making
- Farmer past experience

PRINCIPLES OF AESA BASED IPM

Grow a healthy crop
- Select a variety resistant/tolerant to major pests
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Select healthy seeds/seedlings/planting material
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results.

- If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Farmers should Monitor the field situation of the orchard at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation and P:D ratio
- Take direct action when needed (e.g., remove infested plants)
- Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to
• Herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

• Understand and conserve defenders

• Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem

• Avoid the use of chemical pesticides especially with broadspectrum activity.

• In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in orchard. Insect zoo concept can be helpful to enhance farmers’ skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the orchard and brought to a place for study.

• Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

• Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of apple pests can be divided into 3 categories.

• Parasitoids

• Predators and

• Pathogens

• The general rule to be adopted for management decisions relying on the P: D ratio is 2:1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2:1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavorable, the farmers can be advised to resort to
inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial bio-pesticides and biochemical bio-pesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

**AESAs by extension functionaries/farmers**

During their regular village visits, extension functionaries mobilize farmers, conduct an AESA and critically analyse factors such as the pest population vis-à-vis the defender population and their role in natural pest suppression, the influence of weather and conditions on the likely build-up of the defender/pest population. They may also decide on the basis of the AESA, which uses IPM components like release of defenders, application of neem formulations and other safe pesticides for specific pest situations. This exercise can be repeated by extension functionaries during every village visit to motivate farmers to adopt AESA.

Following a brief exposure to AESA during IPM demonstrations/field training, farmers can implement it on their field. Trained farmers can train fellow farmers, thereby making a large group of farmers proficient in conducting a weekly AESA and deciding on action suited to specific pest situations. A farmer-to-farmer training approach will go a long way in promoting IPM across a large area on a sustainable basis.

**Agro-ecosystem analysis procedures**

AEA is based on the concepts of systems, hierarchies, agro-ecosystem zones, and the system properties of productivity, stability, sustainability and equitability. Ideally, AEA is conducted by a multi-disciplinary group whose joint experience and technical knowledge cover all disciplines relevant to the study. As shown in Figure 1 and Table 1, AEA follows a step-by-step procedure to decide on the purpose of the analysis, to define precisely the system(s) of study, identify its boundaries, its position in the hierarchy of other systems and its major components and their key interactions. As an understanding of the
As an understanding of the system is developed, a limited number of key issues begin to emerge which are then used to guide later analysis and to plan further field, followup studies. As these issues are clarified and understood, key questions and hypotheses are proposed, elaborated and used to identify research and extension priorities.

Figure 1. Procedure for Agro-Ecosystems Analysis

Table 1: Brief Explanation of AEA Procedures

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Definition</td>
<td>Agree on the purpose and objectives of the analysis. Precisely define the system(s) to be studied. Clearly identify and delineate the system’s boundaries (physical, social, administrative, etc.). Describe its position in the hierarchy of other systems.</td>
</tr>
<tr>
<td>System Analysis</td>
<td>Identify and describe the major agro-ecological zones (agro-ecosystems) within the system and the important interactions among them. Analyze each zone in regard to: 1. Space—spatial diversity, sub-systems and key relationships 2. Time—long-term (trends) and short-term (cyclical) changes in the system over time. 3. Flow—the movement of materials, money, information, etc. Both within, into and out of the system. 4. Decisions—the decision making process and choices/options for key decision makers (farmers, government, projects, etc.) Identify the key attributes of the system that contribute either positively and negatively to the productivity, stability, equitability and sustainability of each agro-ecosystem. Identify the key processes determining the overall performance of each agro-ecosystem.</td>
</tr>
</tbody>
</table>
| Identification of development options | As an understanding of the system is developed, a number of key issues, problems and development opportunities begin to emerge. These are further developed and elaborated into hypotheses or ‘key questions’ for
further analysis. System properties analysis is used to identify those attributes of each agroecosystem that impact positively and negatively on productivity, stability, equitability and sustainability. The results of this are used to further develop the key questions. The key questions are interfaced with available technologies to identify appropriate solutions or development options for each question.

| Research Design and Implementation | Proposed development options are assessed using innovation assessment techniques. This provides a rating for each which are then used to set development priorities. High priority development options will include proposals for research, extension and management (district planning) interventions. These are used by the appropriate agency (NAFRI, NAFES or District Authority) to develop appropriate implementation plans. Once these activities have been implemented, their results should be reassessed in the context of AEA and any new lessons used to modify plans. |

Agro-ecosystem analysis implementation stages

AAESA proceeds through a series of stages involving interdisciplinary workshop sessions interspersed with sub-group tasks and fieldwork. The 10 implementation steps in AFZ and AESA are shown above. The main activities, the approximate time taken, and the participants for each of these steps are briefly explained below together with illustrations or examples of each step.

Stage 1 Planning and preparation

- AESA team formation and organisation
- Inform and brief partner institutions (district authorities, boliven leaders, research institutions, etc.)
- Orientation on AEA objectives, procedures and expected outputs
- Explain data collection needs to participants and assign responsibilities
- Arrange logistics for meeting room, materials, supplies, transport, etc.

Stage 2. Definition of Study area

- Identify initial boundaries of the agro-ecosystem zones
- Draft initial transects and descriptions of each zone
- Identify key issues/problems regarding land use and livelihoods for each zone.
- Identify important missing information and data for each zone.
- Assign responsibilities and prepare for follow-up field work.
- (District, development zone, study area description, study area context and an explanation of agro-ecosystem hierarchies; start to check village boundaries within the area of study (using LUP-LA maps & participants knowledge)).

Secondary data collation and organisation.
Spatial data: topography, elevation, slope, geology, soils, climate, land use, watersheds, rivers, admin. boundaries, village locations, roads, etc.
Numeric data: demographic, economic, social, agriculture, climate, etc.

Stage 3. Goal and objectives setting for study Area

- Definition of AEA purpose and objectives by district multi-disciplinary team members (facilitated by the AEA core team)
- Identify key issues and opportunities for agricultural and forestry research and extension that contribute to sustainable agriculture and forestry development.
- To assist the District with socio-economic development planning aimed at poverty alleviation.
- To improve the capacities of district agency staff in implementing AEZ/AEA.
- To strengthen co-ordination between various district projects and other relevant agencies and stakeholders concerned with district development.

Stage 4: gathering and organising Secondary Data

- Forming multi-disciplinary work groups and designating responsibilities for data collection; explanation of secondary data needs; gathering, consolidation and collating secondary data including, socio-economic and biophysical information for the study area; preparation of secondary data spread sheets or lists using Excel program or other appropriate recording methods.
- There are two types of secondary data used for AEZ and AEA:
  - Bio-physical data (maps)
  - Socio-economic data

Stage 5. Agro-ecological zoning

- Explanation of digital maps used in agro-ecological zoning; explanation of zoning methods and tools; identification of boundaries of the agroecosystem zones using manual transparency map overlay method and multidisciplinary group discussions.
- A manual technique is used for agro-ecological zoning using plastic map overlays on district or development zone boundary maps. An overhead projector is used to project enlarged maps for viewing, discussion and making decisions on the ecological zones that exist within the area of study.

Preliminary analysis

Identify initial boundaries of the agro-ecosystem zones
Draft initial transects and descriptions of each zone
Identify key issues/problems regarding land use and livelihoods for each zone.
Identify important missing information and data for each zone. Assign responsibilities and prepare for follow-up field work.

**Stage 6. Description of Agro-ecological Zones:**

- Explain tools for describing agro-ecological zones including, a complete set of hardcopy and transparency maps; undertake agro-ecological zone descriptions using work groups; prepare zone transect tables; prepare information on time, flow, space and decision-making for each agro-ecological zone; check village boundaries and village points using village code data, LUP-LA maps, and participant’s knowledge; and if facilities and resources are available, digitize the agroecological zone boundaries and the village boundaries.

- The tools used to undertake agro-ecological zone descriptions are indicated below.

  **System Analysis Tools Used**

  - Bio-physical maps
  - Zone transect table
  - Historical profiles
  - Seasonal calendars
  - Flow diagrams
  - Venn diagrams

  **System property tables**

**Stage 7. Field work to gather Additional information**

- Gather additional data to improve zone descriptions; market information, farming system information; identify key problems and opportunities with farmers and local stakeholders.

- Field activities are conducted to enhance the quality of the information from the initial descriptions of the agro-ecological zones. Information is verified with villagers and additional information acquired if necessary.

**Stage 8. Identify Key Issues, Proposed Solutions and Development Opportunities for AE Zones**

- Key issue and development opportunity identification and recording; key issue and solution analysis; key issue prioritization and problem solution ranking, using the system property table data for each zone and information gathered in the field.

- The work groups also propose solutions for the issues and opportunities for each zone which are considered and ranked using a scoring system based on factors such as
productivity, stability, sustainability, equitability, cost, time, feasibility and impact on poverty. This information is documented to assist the districts prepare poverty alleviation plans.

Stage 6. Reporting and write-up: Presentation of Results

The results should include:

- A complete report of the AEZ and AEA activities conducted.
- A set of various bio-physical maps for the study area.
- AEZ zone and village boundary maps.
- Agro-ecological zone descriptions (physical and socio-economic).
- Area services maps (water, schools, health centres).
- Area infrastructure maps (roads, tracks, irrigation).
- Demographic maps (village poverty status, ethnicity).
- Socio-economic data sets:
  - Registered villages, population and density, ethnicity and poverty distribution.
  - Village services and infrastructure.
  - Village commerce and tourist sites.
- Data on major agricultural crops and production, agroforestry, and livestock.

- AEZ zone development opportunities.
  - Prioritized key issues and proposed solutions for agro-ecological zones or development zones.

Stage 10 Use of the AESA outputs

- Feed back and follow-up workshops, support to District Authorities on using AEA information in district planning; categorizing key issues into research, extension and development categories; incorporating AEA information in on-going planning and programs with help from resource persons; follow-up on technology domain development and appropriate technology options for defined agro-ecological zones. Draft report for presentation to key stakeholders.
  - Presentation of findings to key stakeholders.
  - Incorporation of feedback from presentation into report.
  - Finalise and translate report.

4. Fieldwork in the system of study

Organize sub-group responsibilities for each agro-ecosystem zone.

Tools used: historical profiles, agro-ecosystem base maps, transects, seasonal.
calendars, flow diagrams, venn diagrams, etc.
Verify and explore key issues with farmers and local stakeholders
Identify key problems and opportunities with farmers and local stakeholders

Stage 5. Systems analysis
Prepare the information on time, flow, space and decision-making
Present and analyse the information in plenary session
Analyse the system properties for each zone (system properties table)
Key question formulation, guidelines and working hypotheses
Problem and solution tree analysis
Innovation assessment and key question prioritisation

Stage 6. Reporting and write-up
Draft report for presentation to key stakeholders
Presentation of findings to key stakeholders
Incorporation of feedback from presentation into report
Finalise and translate report

Stage 7. Use of the outputs
District implements priority programs with help from LSUAFRP
Use of adapted AEA methodology elsewhere in Lao PDR (AEA user manual)
Hold dissemination workshop on AEA methodology for potential users
Plan replication of AEA methodology for other areas

AESA and Farmer Field School
AESA is a season long training activity that takes place in the farmer field. It is season long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner centered, participatory and relying on an experiential learning approach and therefore it has become an integral part of FFS.

AESA case study - Agroecosystem Analysis methodology in vegetable
Agroecosystem analysis helps farmers understand their crop and make appropriate pest management decisions. Ideally, the weekly field school session should start with an Ecosystem Analysis by subgroups, followed by group discussions. This would enable farmers to follow the developments in the ecosystem and take pest management decisions on a weekly basis.

AESA in vegetables (brinjal) can be conducted for all three stages of the crop every week:

**Nursery stage:**
- Observe all nursery beds for insect pests and disease.

**Vegetative stage:**
- Observe 20 plants and scan the entire plant for pests and bioagents.
- For sucking pests, the top two leaves, middle two leaves and bottom leaf are observed.

**Flower and fruiting stage:**
- Observe 20 plants and scan the entire plant for live insect pest attack on flower buds, flower and fruit damage and healthy pests, and available bioagents (all live ones).
- For sucking pests, the top two leaves, middle two leaves and bottom leaf are observed.

**Activities:**
1. Farmers form groups of four to five each. Some groups take the Farmers Practice field and other groups take the IPM field.
2. Each group selects 20 sample plants across the diagonal of the field. To select a plant, walk across the diagonal of the field and choose a plant at every 5 m. In large fields increase the distance between selected plants.
3. Select three leaves from the plant, one from the top, one from the middle and one from the bottom. Pick or turn the leaf and count the number of jassids, whitefly adults and nymphs, and aphids (ignore other sucking pests if not common).
4. Systematically check all leaves and the stem for any predators (moving downward from the top leaf).
5. Count the total number of fruiting parts.
6. Open the bracts of each individual fruiting part and record:
   - Number of fruiting parts with fruit damage
   - Number of fruit borer larvae
   - Any predators
7. Check the ground under the plant and record any predators.
8. Collect the predators in plastic vials to show to other groups.
9. Uproot one brinjal plant for drawing.

10. After 20 plant observations are noted, find a place for the group to sit and make colour
drawings on a large piece of paper. Draw the plant with the correct number of branches. Draw
the sun and indicate with clouds if it is cloudy. Shedding buds are coloured yellow. Draw the
pests on the right hand side of the cotton plant as follows:

11. Sucking pests:
   - Indicate total number found (top two leaves, middle two leaves and bottom one leaf)
   - Indicate the total number of leaves checked (50). (- calculate the average per leaf)

12. Fruit borer larvae:
   - Indicate total number of fruiting parts checked
   - Indicate total number of fruiting parts with fruit borer damage (- calculate percentage of
damaged fruiting parts)

13. On the left hand side of the plant, make a drawing of the predators found. Again, indicate
    total numbers found (and calculate the average per plant). If a lot of weeds are noted, draw
    weeds next to the vegetable plant. Indicate the intensity of disease incidence, rodent damage,
    among others.

14. After the drawing exercise, the following questions are discussed.
    a. Describe the general condition of the plant.
    b. What do farmers think to be the most important factors affecting their crops at this
       stage?
    c. What, if any, measure should be taken?

15. When all groups have finalized their drawings and answered the questions, they present their
    work to each other, explaining the sampling and drawings and discuss the answers to the three
    questions.

16. One group presents its results for each treatment.

17. Each week, a different group member makes the presentation. In Farmer Field Schools, the
    ecosystem analysis drawings of preceding weeks should be available for comparison and a
    discussion of the development of the crop and insect populations. It is easy to forget what the
    field looked like earlier in the season, what insect populations were found and when control
    measures were taken.