Class – B. Sc. (Ag.) VI Semester

E lecture prepared by:

Dr S. P. Vishwakarma, Associate Professor, Department of Agronomy, KAPG College Prayagraj (U P)

"Indices of Agricultural Sustainability"

Agriculture in India is facing several challenges which together manifest in to sustainability issues. The symptoms of agricultural instability are sub-optimal growth, absence of desirable profits and direction or movement of farmers away from the agriculture sector. The causes lie in the depleting status of natural resources and socio-economic conditions of the farmers. Sustainable agriculture is the efficient production of safe, high quality agriculture products in a way that protects and improves the natural environment, the social and economic conditions of the farmers, their employees and local communities, and safeguards the health and welfare of all farmed species. Several frame works and models on measuring agricultural sustainability have been proposed under various production ecosystems.

Therefore, it is inferred that sustainability in agriculture is a complex concept and there is no consensus among scientists about its dimensions. Concerns about sustainability in agriculture systems centre around the need to develop technologies and practices that do not have adverse effects on environmental goods and services, are accessible to and effective for farmers, and lead to improvements in food productivity. It is also acknowledged that sustainability in agriculture systems incorporates concepts of both resilience (the capacity of systems to buffer shocks and stresses) and persistence (the capacity of systems to continue over long periods), and addresses many wider economic, social and environmental challenges.

India has great diversity in agro-climatic zones with as many as 127 zones under five agro-ecosystems such as rainfed, arid, irrigated, coastal and hilly systems. However, data regarding various parameters that are used for sustainability are generally available for the administrative units such as districts and political boundaries such as watersheds or agro-climatic zones. The spatial and temporal changes in sustainability indicators would throw light on the diverse and complex issues of agricultural sustainability in India. Therefore, quantification of sustainability is essential to assess the impact of management practices on actual and potential productivity and environment, following indices are used to assess sustainability-

1. Productivity Index

Productivity per unit of resource can be assessed as:

$$P = Tp / R$$

Where, P = productivity,
Tp = total production,
R = resource used.

2. Total factor Productivity

Total factor productivity (TFP) is defined as the productivity per unit cost of all factors involved (Herdt, 1993).

$$TFP = \frac{Tp}{\sum_{i=1}^{n} (Ri \times Ci)}$$

Where, Tp = total production,
R = Resource used,
C = cost of the resource,
n = number of resources used in achieving total production.

3. Coefficient of Sustainability

Coefficient of sustainability (Cs) is a measure of change in soil properties in relation to production under specific management system (Lal, 1993).

$$Cs = f\ (Oi \times Ad \times Om)\ t$$

Where, Oi = output per unit that maximises per capita productivity or profit,

Ad = output per unit decline in the most limiting or non-renewable resource,

Om = minimum assured output and

t = time (time scale must be carefully selected)

4. Index of Sustainability

Index of sustainability (Is) is a measure of sustainability relating productivity to change in soil and environment characteristics (Lal and Miller, 1993),

$$Is = f\ (Pi \times Si \times Wi \times Ci) / t$$

Where, Pi = productivity per unit input of the limited or non-renewable resource,

Si = Alteration in soil properties,

Wi = change in water resource and quality,

Ci = modification in climatic factor and

t = time.

5. Agricultural Sustainability

Agricultural sustainability (As) is a broad based index based on several parameters associated with agricultural production (Lal, 1993).

$$As = f\ (Pt \times Sp \times Wt \times Cl)\ t$$

Where, Pt = productivity per unit input of the limited or non-renewable resource,

Sp = critical soil property of rooting depth,
Wt = available water retentive capacity of soil,
Cl = climatic factor and
t = time

6. Sustainability Coefficient

Sustainability coefficient (Sc) is a complex and a multipurpose index based on a large number of parameters.

$$Sc = f (Pi \times Pd \times Sp \times Wt \times Ci) t$$

Where, Pi = productivity per unit input of the limited or non-renewable resource,

Pd = productivity per unit decline in soil property,
Sp = critical level of soil property,
Wt = available water retentive capacity of soil,
t = time

Crop Productivity as an Indicator of Sustainability

Measurement of crop productivity is a very good indicator of soil, water, climate and biotic factors which play key role in sustainability. It is important to assess potential vis-à-vis actual productivity. If land availability is limiting factor, appropriate indices of productivity are Land use factor (L), Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER).

a. Land Use factor (L)

The Land use factor is defined as the ratio of cropping period (C) plus fallow period (F) to cropping period (C).

$$L = C + F / C$$

The factor L is, generally higher to low intensity system (shifting cultivation).

b. Land Equivalent Ratio (LER)

LER is the relative land area under sole crop that is required to produce the yields achieved in intercropping. It can be calculating with the help of following formula (Willy and Osiru, 1972) as-

$$LER = \sum_{i=1}^{N} \left(\frac{Yi}{Ym} \right)$$

Where, Yi and Ym = yields of component crops in the intercrop and monoculture systems respectively.

n = number of crops involved.

Or

LER =	**Yield of component crop A in intercropping** / **Yield of component crop A in sole cropping**	+	**Yield of component crop B in intercropping** / **Yield of sole crop B in in sole cropping**

If LER is less than 1 inter cropping is harmful. If LER is 1 there is no advantage and if LER is more than 1, intercropping is advantageous.

c. Area Time Equivalent Ratio (ATER)

As the crops involved vary widely in their maturity period, ATER index considers the crop duration (Heibsch and Mc Collum, 1987).

$$ATER = \frac{1}{t} \sum_{i=1}^{n} \left(\frac{d * Yi}{Ym} \right)$$

Where, d = growth period of crop in days and

T = time in days for which the field remain occupied (growth period of the longest diatom crop).

Numerical values of ATER approaches that of LER for a mixture consisting of crops of approximately identical growth periods i.e. when t = d in comparison, productivity can also be expressed in terms of the resource use efficiency of the most limiting resource, (water, nutrients, labour etc.).

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