# SOIL-CROP SUITABILITY CLASSIFICATION FOR BANGLADESH



FAO/UNDP Agricultural Development Adviser Project
(BGD/81/035)
Agriculture & Forest Division
Ministry of Agriculture
Dhaka

1985

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(Second edition, revised)

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Typed by :

Md. Akbar Ali,

P.A. to the Director,

Soil Resources & Development Institute,

Dhaka - 15

## PREFACE TO THE FIRST EDITION (1980)

This paper deals with an outline of, and suggestions for, a revised soil suitability classification for Bangladesh. Its principles are based on a classification system used by the present author in Papua New Guinea (2). It has the advantage over the system presently used by the Soil Survey Department that each soil is categorized for a number of specific properties that determine its suitability. Not only does this make comparison between soils in terms of suitability relatively easy but it also ensures that similar soils will always receive the same suitability rating.

The system will be used to record soil properties for computer storage, based on the information provided in the reconnaissance soil survey reports. Apart from this, it is hoped that the system will at least provide 'food for thought' in discussions on soil suitability, crop suitability or land capability and make officers more aware of the effect of soil properties on crop growth and yields. Ideally, the system should also be used during soil surveys, rating each each soil described in the field for its land factors.

M.F.W. Zijsvelt,
Senior Officer,
FAO/UNDP Soil Survey Interpretation Project
(BGD/78/012)

## PREFACE TO THE SECOND (REVISED) EDITION

A number of modifications has been made to the land factor and limitation ratings given in the first edition where experience has shown that certain crops had been unduly penalized by the strict application of the system. The basic structure of the system has not been amended, however.

The revised edition includes only Chapters 1-7 of the original edition. The order of some of the chapters has been re-arranged, and the original chapter 7 has been divided into two separate chapters. The original chapters 8-11 which have been omitted dealt with the application of the crop suitability rating system to land capability classification and provided examples of crop suitability ratings for several soil series as well as of crop suitability maps for the Thakurgaon soil survey report. Because of the change in contents, the title of the publication has been changed from the original 'A revised soil suitability and land classification for Bangladesh' to the more restricted title used for the present edition.

The revised classification given in this second edition is the one used for assessing crop suitability within each of the agro-ecologioal subregions shown on the 1:1 million Agro-ecological Zones Map of Bangladesh (1985).

H. Brammer,
Project Manager,
FAO/UNDP Agricultural Development Adviser Project
(BGD/81/035)

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# 1. INTRODUCTION

A study of published soil survey reports shows considerable variation in land capability and crop suitability ratings assigned to similar soils. Discussions with officers from the Department of Soil Survey and experience during training programmes also indicated a number of difficulties in applying the classification system introduced in the 1960s. The main problem appears to be a lack of qualification and quantification. Although the existing classification mentions a number of land factors, officers are likely to have different interpretations for such statements as 'good moisture holding capacity', 'low to moderate fertility' and 'poor to moderate yields'. As a first step towards achieving a better understanding and greater uniformity of ratings, it seems important, therefore, to :

- define the land factors that determine soil suitability in Bangladesh;
- specify for each land factor a number of classes; and
- rate each class according to its limitation for land use types and individual crops.

The revised land capability and soil suitability classification should be seen as a first attempt towards quantitative land classification which, eventually, should replace the existing classification system. This publication outlines the selected land factors, gives guidelines for their determination and discusses their effect on land use types and individual crops. The classification can also be used to rate soils according to their suitability for particular rotations. When the growing seasons of individual land use types do not overlap, a recommendation for specific rotations is possible. A soil rated as highly suited for dryland rabi crops and broadcast wetland kharif crops is, obviously, also highly suited to a rotation of aus/jute followed by rabi crops. The climate factor has been specifically introduced to rate soils for their suitability for rainfed transplanted aus and aman rotations in different parts of the country.

In order to determine soil-crop suitability ratings, the following steps have to be taken.-

i) Determine the land factor classes and their ratings for the soil under consideration, as explained in Chapter 4.

ii) Determine the limitations posed by the land factor ratings for the land use type or individual crop under consideration, as explained in the tables of Chapter 8.

iii) Determine the soil suitability rating according to Table 1 in Chapter 7.

## 2. LAND FACTORS AND KINDS OF LAND USE

The following land factors are taken into consideration :-

p - soil permeability
d - effective soil depth
m - available moisture holding capacity
n - nutrient availability
a - soil reaction
s - soil salinity
t - topsoil consistence and bearing capacity
w - drainage
i - depth of inundation
f - flood hazard
e - slope
c - climate

It is thought that these twelve land factors can adequately define soil suitability in Bangladesh for eight land use types and for all individual crops. A land use type is defined as a group of crops having similar environmental requirements and which are grown during a specific season. The following land use types have been distinguished :-

R - dryland rabi crops
K - dryland kharif crops
P - perennial crops
W - broadcast wetland kharif crops
B - boro
A - transplanted aus
T - transplanted aman
U - transplanted aman (following aus)

Each land use type comprises a number of individual crops, as detailed in Tables 8A and 8B. Transplanted aman, aus and boro have all been divided into three varieties; broadcast wetland kharif crops include broadcast aus, jute and broadcast aman; and perennial crops comprise those that occupy the land for an annual period or more. Transplanted aman has also been considered separately as a single crop (T) and as a component of the common aus-t.aman rotation (U). Dryland rabi and kharif crops include a wide range of annual crops grown during the dry season and the monsoon season respectively.

In principle, only two levels of management have been considered. Traditional management without irrigation assumes rainfed cropping with the aid of the country plough, absence or only limited use of manures and fertilizers, and lack of large-scale water control (whether flood protection, drainage and/or irrigation).

The corresponding suitability ratings indicate the basic potential of the soils for what is still the most common kind of land management in Bangladesh.

A second, and increasingly, common form of management can be described as traditional management with irrigation. Land preparation is still carried out with the country plough and fertilizer use is inadequate for optimum yields, but small-scale irrigation from low-lift pumps, deep and shallow tube-wells, or hand tube-wells, is being practised. Water management, however, is still relatively poor.

It is important to realize that the system rates soils in their actual condition, with or without irrigation. If improvements are made in the future, then a new rating for the changed conditions will need to be made. For example, the provision of flood protection works to an area would reduce the present drainage, inundation and flood-hazard limitations on soils within the project boundary. Similarly, the introduction of new crop varieties with environmental requirements or adaptability different from existing varieties would require new ratings to be made to suit the changed environmental limits of the crop/variety. In this respect, it is important that both the classification itself and its application to specific areas should be kept constantly under review and amendments made as and when necessary.

In the FAO publication 'A Framework for Land Evaluation' ( 1 ), it is recommended that the comparison of land with land use should be carried out in terms of land qualities. A land quality is defined as 'a complex attribute of land which acts in a distinct manner on the suitability of land for a specific kind of use'. Land qualities are determined by the interactions between specific land characteristics which are defined as 'attributes of land that can be measured or estimated'. The land factors discussed in the present publication could be interpreted partly as land qualities and partly as land characteristics. To avoid confusion, therefore, the latter two terms have not been used and only land factors will be discussed. Table 2.1 shows a correlation between a number of land qualities as listed by FAO and the land factors used in this publication.

It is stressed that the concepts of the revised classification are based on what is known of, and grown on, the soils of Bangladesh. Criteria, ratings and

limitations reflect local conditions. In particular, the soils information is mainly based on field descriptions of the upper fifty inches (127 cm) of the soil profile. Therefore, land factors can be determined from ordinary soil profile descriptions and laboratory data are generally not required (although their use might be helpful where they are available).

Table 2.1

| Land qualities (FAO, 1976) | Land factors |
|---|---|
| Moisture availability | effective soil depth (d)<br>available moisture holding capacity (m)<br>climate (c)<br>drainage (w) |
| Nutrient availability | nutrient availability (n)<br>soil reaction (a) |
| Oxygen availability | soil permeability (p)<br>drainage (w)<br>depth of inundation (i) |
| Adequacy of foothold for roots | effective soil depth (d) |
| Conditions for germination | topsoil consistency and bearing capacity (t) |
| Workability of the land | topsoil consistency and bearing capacity (t) |
| Salinity | soil salinity (s) |
| Soil toxicity | soil reaction (a) |
| Resistance to soil erosion | soil permeability (p)<br>slope (e) |
| Flooding hazard | depth of inundation (i)<br>flood hazard (f) |

# 3. LAND FACTOR RATINGS

This chapter provides a general discussion of the land factors. Detailed guidelines for the determination of the land factor ratings are presented in chapter 4.

## 3.1 Soil permeability

Three classes of permeability have been used, generalized from those of the USDA Soil Conservation Service. Lack of information prevents the use of the standard USDA classes.

Together with the drainage and inundation factors, permeability determines the availability of oxygen in the root zone. Removal of excess moisture from the soil surface and the soil profile depends mainly on the rate of permeability and the position of the soil in the landscape. On high-lying land, rapidly permeable soils will generally not have water standing on the surface after heavy rainfall, and excess moisture in the root zone will be drained in a matter of a few hours. Slowly permeable soils, on the other hand, will have water standing on the surface for a period of time and may remain waterlogged for a few weeks after heavy rainfall. Actual durations of inundation and waterlogging are reflected in the inundation and drainage ratings.

Under traditional management without irrigation, permeability will only be assessed in relation to non-seasonal rainfall and the ability to puddle the soil. However, when irrigation is part of land management, permeability is more important, particularly in the case of transplanted rice crops which can have a high irrigation requirement.

## 3.2 Effective soil depth

The soil depth ratings do not simply indicate the depth to bedrock or cemented material. It has been assumed that, with increasing compactness and consistence, the effective rooting depth will decrease, particularly in the case of annual dryland crops. For example, root development will not be hampered in a fifty inches deep profile of friable sandy loam. On the other hand, roots will not easily penetrate into a very firm clay and, consequently, depending on the crop, the effective soil depth would be less than fifty inches. Soils that have bedrock or

cemented material within the upper fifty inches will either receive a 'd3' or 'd4' rating. Soils with a well-developed ploughpan receive a 'd5' rating.

3.3 Available moisture holding capacity

The available moisture holding capacity is determined for the calculated effective soil depth. Volume percentage available moisture has been determined in the laboratory for a large number of soil samples, representing all textural classes and parent materials. On the basis of these figures, five classes have been established, ranging from more than 16 inches (400mm) to less than 4 inches (100mm) of available moisture. At first glance, the available moisture figures and the selected class limits might appear rather high. However, research over a number of years has repeatedly shown that Bangladesh's floodplain soils in particular have very high available moisture holding capacities.

With regard to the class limits, it must be realized that these represent 'total available moisture' rather than 'readily available moisture'. The latter is generally only 50 to 60 percent of the total available moisture; plants find it increasingly difficult to obtain moisture beyond these levels.

3.4 Nutrient availability

Little is known yet about the relationship between soil nutrient status and crop yields in Bangladesh. Fertilizer recommendations are blanket ones, applying to all soils for particular crops. Never-the-less, it would be wrong to disregard the soil fertility aspect. Initially, for this classification, rather elaborate ratings were developed, based on cation exchange capacity and percentage base saturation. This did not appear satisfactory, because it lost touch with reality. Therefore, a more simple nutrient classification was developed by making a separation between soils that have low cation exchange capacities, low base saturation and/or low amounts of weatherable minerals, and soils that do not have these properties.

Soils developed in coarse textured parent material - sand, loamy sand and sandy loam - have a small clay fraction, a CEC generally well below 10 me/100 gr. soil and, in addition, the amount of weatherable minerals is relatively low. Soils developed in strongly weathered Madhupur Clay have a very low mineral reserve, are known to fix phosphates and have a clay fraction dominated by

kaolinite. Ferrolysed soils have an inert clay fraction with a low cation exchange capacity. All other soils in Bangladesh have very high to moderate cation exchange capacities and high mineral reserves.

3.5 Soil reaction

In rating the soils for acidity/alkalinity, emphasis has been given to the reaction of the A horizon. This is achieved by giving this horizon more weight than the reaction in the deeper parts of the soil. Ratings are based on the pH determined in the field and a correction must be applied when only the laboratory pH is known.

3.6 Soil salinity

Saline soils are mainly found on land which is subject to tidal flooding with salt water for part or all of the year and on land where the groundwater is to some extent saline: i.e., on the Ganges tidal floodplain, the Young Meghna estuarine floodplain and near river mouths on the Chittagong coastal plain. The salinity has only a limited effect on cropping because most salts are washed out by heavy monsoon rainfall or flooding with fresh river water. Therefore, soils that are saline in the dry season generally become non-saline in the root zone during the monsoon season.

During the dry season, capillary movement of moisture to the soil surface concentrates salts in a thin layer at the surface. Where the salt concentration occurs early in the dry season, rabi crops cannot be grown. On such land, as well as on soils where salinity developes later in the dry season, kharif crops cannot be sown or transplanted until there has been sufficient pre-monsoon or monsoon rainfall to dilute or leach the salts from the topsoil.

Accumulation of exchangeable sodium is restricted to very small patches of Ganges river floodplain soils and is insignificant in terms of acreage. Such soils have a very high pH ~~in~~ in the surface soil and will receive an 'a4' rating, with limitations assigned accordingly. Too little is known about them to introduce a separate 'soil sodicity' land factor.

3.7 Topsoil consistence and bearing capacity

This land factor serves to evaluate the workability of the soils. Organic soils have a low bearing capacity which adversely affects the trafficability of

the land during land preparation and planting. Heavy consistencies in mineral topsoils indicate the likelihood of tillage difficulties. Such soils are also difficult to work into a fine tilth which will particularly affect the germination and early development stage of crops which are broadcast sown.

3.8 Drainage

The drainage classes are the same as those used to describe soils in the field. Poorly drained soils have been subdivided into early/normal and late draining soil phases respectively. The definitions of the drainage classes are as follows .-

Well drained : water stands on the surface for not more than a few hours and the soil does not remain saturated for more than 2-3 days after heavy rainfall.

Moderately well drained : water remains on the soil surface for a few days following heavy rainfall and the soil may remain wet for up to two weeks at a time during the monsoon season.

Imperfectly drained : the soil remains wet for several weeks during the monsoon season and water may stand on the surface for up to two weeks at a time following periods of heavy monsoon rainfall.

Poorly drained : the soil remains wet for several weeks during the monsoon season and is flooded for more than two weeks but not for the whole year.

Very poorly drained : the soil remains wet throughout the year.

3.9 Depth of inundation

Inundation may be caused by ground-water levels rising above the land surface, by ponding of rain water, or overflow from a river. Water levels rise and fall slowly, there is not more than negligible flow of the water, and water stands on the surface for more than 2-3 days at a time. Poorly and very poorly drained soils, by definition, are inundated during part or all of the year respectively; imperfectly drained soils can be inundated occasionally; and moderately well and well drained soils are never inundated. The depth of inundation is particularly important in relation to the type of kharif rice crop to be grown.

3.10 Flood hazard

The flood hazard is evaluated through the number of 'disastrous' floods which occur during a period of time. Disastrous flooding can be caused by rivers spilling over their banks, eroding land or depositing fresh alluvium on neighbouring land; by flash floods flowing from adjoining hill areas; by rain-water accumulating in deep floodplain basins; or by tidal storm surges associated with cyclones. In particular, late dry season crops such as boro, and the early kharif crops such as aus and jute, can be damaged by flooding; and later river floods and flash floods from adjoining hill areas can damage transplanted aman. On the other hand, early and mid-dryland rabi crops are not normally affected.

3.11 Slope

The land factor 'slope' is used to evaluate both erosion hazard and ease of land management. Although it is realized that there are better methods for evaluating erosion hazard, lack of relevant information does not allow this at present. On the other hand, climate - rainfall distribution and intensity - and soil are relatively uniform in the hill areas and the slope percentage is at least one of the dominant factors which determine the erosion hazard.

3.12 Climate

A tropical monsoon climate with hot, wet summers and cool, dry winters prevails throughout Bangladesh. Only those crops that can be grown under these climatic conditions have been evaluated. For rainfed agriculture - still by far the most common form of agriculture in Bangladesh - the distribution of rainfall over an annual period is very important, particularly since it determines whether one or two good kharif rice crops can be grown. Only in the north-east of the country is the rainy season sufficiently long to allow two transplanted rice crops of normal duration to be grown reliably in rotation without irrigation, but the excessive rainfall, cloudiness and humidity in this area provide a limitation. In the centre of the country, aus and t. aman can be grown in rotation only when quick-maturing varieties are grown. In the west, the rainy season is too short and uncertain for more than one kharif rice crop to be grown reliably without irrigation. Where irrigation is available, the length of the growing season is irrelevant, but excessive rainfall remains a constraint for paddy crops in the east and for kharif dryland crops in all areas.

The following symbols and terms are used for describing land factor ratings. Guidelines for rating soils for crop suitability classification are given in Chapter 7. The relationships between individual land factors and soil-crop suitability are discussed in Chapter 5.

3.13 Descriptive terms for land factor ratings

p0 rapidly permeable soil

p1 moderately permeable soil

p2 slowly permeable soil

d0 deep and friable soil

d1 deep and firm soil

d2 deep and very firm soil

d3 shallow soil

d4 very shallow soil

d5 soil with dense ploughpan

m0 very high available moisture holding capacity

m1 high available moisture holding capacity

m2 moderate available moisture holding capacity

m3 very low available moisture holding capacity

m4 very low available moisture holding capacity

n0 relatively fertile soil

n1 relatively infertile soil

a0 medium acid to neutral soil

a1 mildly to moderately alkaline soil

a2 very strongly acid to strongly acid soil

a3 extremely acid soil

a4 strongly to very strongly alkaline soil

s0 non-saline soil

s1 very weakly saline soil

s2 weakly saline soil

s3 moderately saline soil

s4 strongly saline soil

t0 soil without tillage problems

t1 soil with moderate tillage problems

t2 soil with serious tillage problems

t3 organic soil

w0 well to excessively drained soil

w1 moderately well drained soil

w2 imperfectly drained soil

w3 early to normal draining, poorly drained soil

w4 slow draining, poorly drained soil

w5 very poorly drained soil

i0 no inundation

i1 very shallow inundation

i2 shallow inundation

i3 moderately deep inundation

i4 deep inundation

i5 very deep inundation

f0 no flood, river erosion or storm surge hazard

f1 slight flood, river erosion or storm surge hazard

f2 moderate flood, river erosion or storm surge hazard

f3 severe flood, river erosion or storm surge hazard

f4 very severe flood, river erosion or storm surge hazard

e0 level and nearly level

e1 gently sloping and undulating

e2 sloping and rolling

e3 moderately steep and hilly

e4 steep

e5 very steep

c0 long rainy season, short dry season

c1 about similar length of rainy and dry seasons

c2 short rainy season, long dry season

These classes are described in detail in Chapter 6.

## 4. GUIDELINES FOR DETERMINING LAND FACTOR RATINGS

These guidelines provide instructions for the determination of land factor ratings which should be matched with crop requirements for obtaining the soil suitability. For further clarification, the land factor ratings of one particular soil series - Farabari series as described in the Thakurgaon soil survey report - are explained in detail in Chapter 6.

When using the guidelines during a soil survey, it is desirable that each profile described in the field is rated for its land factors. On the other hand, when using the guidelines for updating crop suitability ratings in the already published soil survey reports, there is only one representative profile for each soil series. In such cases, it is important that the ratings should reflect the 'average' representative profile, which is often explained in the 'Range of Characteristics'. For example, if the typical profile consists of silt loam throughout, but the range of characteristics indicates that, below 20 inches, the texture varies from silt loam to loamy sand, in the calculation of available moisture should not be based only on silt loam but on a value half-way between that of silt loam and loamy sand.

The guidelines should be followed as strictly as possible. Personal judgement, however, should be used when boundary cases are involved, when there is conflicting evidence, or when there are unforeseen circumstances not covered by the land factors considered. Also, when using these guidelines for rating soils within an agro-ecological unit (or within an Upazila lying wholly within a single agro-ecological unit), any specific conditions known to apply to that unit/Upazila should be taken into account: e.g., if the soils are known to be shallower than in the soil association as a whole; or if local flood-protection/drainage schemes have reduced the flood hazard previously existing and described in the soil survey report for the area.

1. Permeability

| Permeability rating class | rapid (more than 305 cm/day 120 in./day) | moderate (12-305 cm/day 4.8-120 in./day) | slow (less than 12 cm/day 4.8 in./day) |
|---|---|---|---|
| | 0 | 1 | 2 |

(i) If laboratory data are available, these should be applied in rating the soil.

(ii) If no laboratory data are available, the table below should be used as a guideline.

(iii) If a ploughpan is present, (i.e., if the soil has a 'd5' rating), only the soil below the ploughpan should be considered.

(iv) The permeability rating of a soil profile is determined by the rate of permeability of the slowest permeable layer in the upper fifty inches.

| Permeability | Soil properties |
|---|---|
| Rapid | - loose gravel and coarse sand;<br>- loose to firm fine sand to fine sandy loam but not very fine sandy loam;<br>- friable, porous, structured, and strongly weathered Madhupur Clay;<br>- friable, porous sandy loams and sandy clay loams on Dupi Tila, Tipam and Surma formations. |
| Moderate | - moderately fine and fine Ganges alluvium located in Medium Highland and Highland positions;<br>- all other medium and moderately fine textured alluvium of at least moderate porosity and structure;<br>- partially weathered, mottled grey, red, brown and yellow Madhupur Clay;<br>- moderately fine and fine textures of siltstone and shale on Tipam and Surma formations. |
| Slow | - unripened and/or strongly stratified medium, moderately fine and fine textured alluvium;<br>- fine-textured Ganges alluvium in Medium Lowland and Lowland positions;<br>- fine-textured alluvium from all other floodplains;<br>- unweathered Madhupur Clay. |

2. Effective soil depth

| Effective soil depth d rating | more than 48 inches 0 | 36-48 1 | 24-36 2 | 10-24 3 | less than 10 inches 4 | very firm/hard ploughpan 5 |
|---|---|---|---|---|---|---|

(i) The effective soil depth is calculated as the sum of the products of depth coefficients and thickness of the soil layers to which these coefficients apply.

(ii) Depth coefficients are mainly determined by soil consistence and are set out in the table below.

(iii) In addition to their calculated effective soil depth rating, soils with a very firm and/or hard ploughpan should always be given a 'd5' rating.

(iv) When determining suitability of the soils for land use types or individual crops, the limitations indicated by the 'd5' rating should be used. The calculated depth rating must be determined for calculating available moisture, independent of the soil having a 'd5' rating or not.

(v) Soils with 'd3' and 'd4' ratings are only found in the northern and eastern hills where hardrock or lateritic pans can occur within 25 inches from the surface. In the floodplains or on the Madhupur and Barind tracts, soils have always a 'd0', 'd1' or 'd2' rating, or, when a well developed ploughpan is present, a 'd5' rating.

(vi) Only the upper fifty inches of the soil profile should be considered for calculation of the effective soil depth. Material occurring below a layer with a depth coefficient of 0.00 should be excluded from the calculation.

(vii) When matching land factor ratings with requirements for transplanted rice crops, i.e., boro, aus and aman, and the soil has a 'd5' rating, the permeability rating should not be considered; in other words a '0' limitation is given, except for soils developed in Ganges floodplain alluvium.

| Depth coefficient | Soil consistency |
|---|---|
| 1.00 | loose to slightly firm; loose to slightly hard; nonplastic, slightly plastic and nonsticky to sticky |
| 0.75 | firm to very firm; hard to very hard; slightly plastic and very sticky; plastic and nonsticky to very sticky; very plastic and nonsticky to sticky; strongly weathered rock. |
| 0.50 | very firm to extremely firm; very hard to extremely hard; very plastic and very sticky; partially weathered rock that can still be augered. |
| 0.00 | massive rock or comented material that can not be augered. |

3. Available moisture holding capacity

| Available moisture holding capacity m rating | more than 16 inches 0 | 12-16 1 | 8-12 2 | 4-8 3 | less than 4 inches 4 |
|---|---|---|---|---|---|

(i) The available moisture holding capacity is determined by the sum of the products of the volume percentage available moisture and the thickness of the respective soil layers.

(ii) All soil material below the calculated effective soil depth must be excluded from the calculation.

(iii) In the case of soils with a 'd5' rating, available moisture should be calculated to the 'without ploughpan' effective soil depth.

(iv) If the parent material is raw, stratified alluvium, the calculated available moisture in relevant layers should be reduced by 50 percent.

(v) In sandy over loamy, or in sandy over clayey phases, the calculated available moisture in the loamy or clayey part should be reduced by 50 percent.

(vi) The table below sets out the volume percentage available moisture according to soil parent material and textural class. The data are averages from laboratory determinations.

| Textural class | Available moisture holding capacity volume % | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| coarse sand, gravel | 6 | 4 | 4 | | 3 |
| sand, loamy sand | 12 | 8 | 5 | | 5 |
| sandy loam (but not very fine sandy loam) | 15 | 12 | 12 | | 10 |
| loam, very fine sandy loam | 30 | 25 | 22 | 20 | 18 |
| silt loam | 32 | 25 | 22 | 22 | 20 |
| sandy clay loam | 20 | | | | 15 |
| clay loam | 26 | 20 | 18 | 15 | 15 |
| silty clay loam | 26 | 20 | 18 | 15 | 15 |
| sandy clay | | | | | 10 |
| silty clay | 22 | 15 | 12 | | 12 |
| light clay (less than 60% clay) | 18 | 15 | 12 | | 12 |
| heavy clay (more than 60% clay) | 15 | 12 | 10 | | |
| strongly weathered Madhupur silty clay and clay | | | | 12 | |
| partially and unweathered Madhupur silty clay and clay | | | | 10 | |

1: Tista, Old Himalayan Piedmont, Karatoya-Bangali, Ganges tidal, Jamuna, Old and Young Meghna Estuarine alluvia.

2: Ganges river, Atrai, Old Brahmaputra, Lower and Middle Meghna, Surma-Kusiyara, and Chittagong Coastal Plain alluvia.

3: Northern and Eastern Piedmont, Minor Eastern Rivers and Madhupur Clay alluvia.

4: Madhupur Clay.

5: Tertiary hills.

4. Nutrient availability

| Nutrient availability n rating | low 1 | high 0 |
|---|---|---|
| Classification | - soils developed in coarse textured floodplain alluvium;<br>- soils developed in strongly weathered Madhupur clay;<br>- soils that have been strongly ferrolysed;<br>- soils with an umbric epipedon on the Old Himalayan Piedmont plain;<br>- soils developed in sandstone of the Tertiary hills | all other soils |

(i) In the case of coarse textured floodplain alluvium, sand, loamy sand or sandy loam (but not fine and very fine sandy loam) must start within 10 inches from the soil surface and continue for a least 12 inches.

(ii) All soil series recognized in Madhupur Clay, except Demra, Dudnai, Jhikra and Bhatpara, should be given an 'n1' rating. All these soils are either undergoing ferrolysis or have already reached an ultimate stage of weathering, as witnessed by low CEC, base saturation and phosphate fixation.

(iii) Strongly ferrolysed soils of the Madhupur and Barind tracts have been classified as Albaquepts; in addition, there are some old floodplain soils in which ferrolysis can be recognized by the bleached surface horizon and silt specks in the subsoil.

(iv) Soils found on Old Himalayan piedmont alluvium which are classified as Haplumbrepts or Humaquepts should also be assigned an 'n1' rating. These soils are strongly acid, and have low base saturation and CEC.

5. Soil reaction

| Soil reaction (pH) | less than 4.5 | 4.5-5.5 | 5.6-7.3 | 7.4-8.4 | more than 8.4 |
|---|---|---|---|---|---|
| a rating | 3 | 2 | 0 | 1 | 4 |

(i) To determine the soil reaction rating, the pH determined in the field should be used.

(ii) If only the laboratory pH is known, the pH of the A horizon should be increased by 0.5 and that of the B and C horizons by 1.0, except that the adjusted pH should not be raised higher than 8.0. No correction should be made in the case of well drained and moderately well drained soils and in the case of undeveloped soils with A-C profiles; in all these soils, the laboratory pH is representative for the field pH.

(iii) To calculate the 'a' rating, the pH of the Ap or A1 horizon, or the weighted mean pH of the Ap1 and Ap2 horizons, should be multiplied by 2, added to the weighted mean pH of the part to 24 inches, and the total divided by 3.

(iv) That part of the soil below the effective soil depth should be excluded from the calculation.

6. Soil salinity

| Conductivity millimhos/cm | less than 2 | 2-4 | 4-8 | 8-15 | more than 15 |
|---|---|---|---|---|---|
| s rating | 0 | 1 | 2 | 3 | 4 |

(i) The salinity ratings apply to wholly saline soils as well as to soils that are only saline above a depth of 24 inches.

(ii) If a soil is only saline between 24 and 50 inches, the rating should be reduced by 1, i.e., becomes one unit lower.

(iii) Salinity of the soils is indicated by the chemical analyses and normally reflects the situation during mid to late dry season when salinity is most severe.

(iv) If no chemical data are available, but a soil has been placed in a saline phase, ~~following~~ the following criteria apply:

- weakly or slightly saline phase : rating 's1'
- saline or moderately saline phase : rating 's2'
- strongly saline phase : rating 's3'
- very strongly saline phase : rating 's4'

7. Topsoil consistence and bearing capacity

| Soil condition | Mineral surface soil: not more than slightly firm, slightly sticky, slightly plastic, hard | firm, very firm, sticky, plastic, hard, very hard | extremely firm, very sticky, very plastic, extremely hard | organic material to at least 10 inches below the surface |
|---|---|---|---|---|
| t rating | 0 | 1 | 2 | 3 |

(i) Ratings are self-explanatory and apply to the A horizon only.

(ii) If in doubt, preference should be given to the moist consistency description.

(iii) Soils that have an organic surface layer less than 10 inches thick should be assigned a 't1' rating.

8. Drainage

| Drainage class | well | moderate | imperfect | poor, but surface drained before mid-November | poor, but surface drained after mid-November | Very poor |
|---|---|---|---|---|---|---|
| w rating | 0 | 1 | 2 | 3 | 4 | 5 |

(i) The drainage class designation should be inferred from information in the soil association tables and typical profile descriptions.

(ii) Medium Highland soils can never be imperfectly drained or better.

(iii) Slow draining phases should always be given a 'w4' rating.

(iv) Very poorly drained phases of normally poorly drained soils should be given a a 'w5' rating.

(v) Soils with a drainage rating other than 'w5' are not suitable for boro if no irrigation water is available.

(vi) When matching land factor ratings with requirements of the eight land use types and individual crops, the permeability rating should be disregarded - in other words always has a '0' limitation - when the soil has a 'w5' rating.

9. Depth of inundation

| Depth of inundation | no inundation | less than 1 foot | 1-3 | 3-6 | 6-10 | more than 10 feet | less than 3 feet |
|---|---|---|---|---|---|---|---|
| i rating | 0 | 1 | 2 | 3 | 4 | 5 | 6 |

(i) In order to determine the 'i' rating correctly, it is essential to carefully consult the description of the environmental characteristics given after each profile description.

(ii) Well ('w0') and moderately well ('w1') drained soils should always receive an 'i0' rating.

(iii) Imperfectly drained ('w2') soils that are inundated for not more than two to three days should be assigned an 'i0' rating. Imperfectly drained soils that are inundated for more than two to three days at a time should receive an 'i1' rating. If the duration is not indicated, soils with a coarse or medium textured subsoil (except silt loam) should receive an 'i0' rating; those with finer textured subsoils should receive an 'i1' rating.

(iv) In the case of Medium Highland soils, when the environmental characteristics state that the soil is inundated by not more than 3 feet of water - in other words both 'i1' and 'i2' ratings would be possible - the soil should be rated as 'i6'.

(v) When determining the suitability for the generalized land use types and individual crops of a soil rated as 'i6', it is necessary to consider both the limitations as presented by 'i1' and 'i2' ratings. When calculating areas of suitability classes, the area occupied by a soil rated 'i6' is divided to assign 25 percent to the 'i1' and 75 percent to the 'i2' ~~ratings~~ rating: (see example page 41).

10. Flood hazard

| Frequency of occurrence of flood hazard in a 10-year period | none | once | twice | 3-4 times | 5 times or more |
|---|---|---|---|---|---|
| f rating | 0 | 1 | 2 | 3 | 4 |

(i) Flood hazard is evaluated by the number of 'disastrous' floods which occur in a 10-year period.

(ii) The following events indicate 'disastrous' flooding:

- flooding accompanied by deposition of fresh alluvium, i.e., soils that have received an x-phase designation;
- flooding accompanied by river erosion, i.e., soils that have received an x-phase designation;
- rapidly rising and/or flowing flood water, i.e., soils that have received a z-phase designation;
- storm surges associated with cyclones, i.e., soils that have been placed in a 'storm surge hazard' phase.

(iii) In a case where the degree of hazard is not indicated at the phase level, the soil should be assigned an 'f2' rating.

(iv) In a case where the degree of hazard is indicated, the following rules apply :

- slight receives 'f1' rating;
- moderate receives 'f2' rating;
- severe receives 'f3' rating;
- very severe receives 'f4' rating.

(v) On account of the cyclone hazard, all soils in the old Khulna, Barisal, Patuakhali, Noakhali and Chittagong districts should be given an 'f1' rating if no other flood hazards have been indicated.

11. Slope

| Slope % | less than 3 | 3-8 | 8-16 | 16-30 | 30-45 | more than 45 |
|---|---|---|---|---|---|---|
| e rating | 0 | 1 | 2 | 3 | 4 | 5 |

(i) Percentage slope is used both to evaluate erodibility and ease of management. Although somewhat unsatisfactory, slope appears the most useful criterion to investigate erodibility. Areas of possible erosion hazard are restricted to the hills where both soils and rainfall patterns are rather uniform and the slope percentage, therefore, will greatly determine the erosion hazard.

(ii) The suggested ratings apply to stable slopes; if there are indications that a slope is unstable, the rating should be one unit higher. For example, a stable slope of 6% receives an 'e1' rating; an unstable slope of the same steepness will be rated as 'e2'.

(iii) Instability of slopes may be indicated by lack of topsoil development, low infiltration rates, excessive root exposure and the absence of leaf litter.

(iv) Irregular relief is not taken into account for evaluations under traditional management without irrigation. Only when considering management with irrigation is this factor considered, as described below under (v).

(v) When considering soil suitability with irrigation, the suitability rating of soils that have an irregular relief, man-made, narrow extent or terraced phase should be increased by one unit: i.e., S1 becomes S2, S2 becomes S3, etc. Soils that are placed in the broadly and closely dissected phases will have their suitabilities increased by 2 units; i.e., becomes S3 and S2 becomes S4, etc.

12. Climate

| Climate | dry season: less than 5 months; monsoon season: more than 6 months | dry season: 5 or 6 months; monsoon season: 5 or 6 months | dry season: 5 months or more; monsoon season: 4 months or less |
|---|---|---|---|
| c rating | 0 | 1 | 2 |

(i) A month with rainfall of less than 4 inches is considered part of the dry season. A month with a rainfall of 8 inches or more is considered part of the monsoon season.

(ii) c ratings have been determined on an Upazila by Upazila basis. In case a soil association is located in more than one Upazila having different climatic ratings, the most common rating should be applied when considering the District as a whole.

## 5. LAND FACTORS AND LIMITATIONS FOR LAND USE

The land factors can be used to assess the suitability of any soil for the eight land use types described in Chapter 2 or for any of the 33 individual crops and crop groups indicated in Tables 8A and 8B. For assessing the influence of the land factor classes on soil suitability and crop growth, a number of assumptions has been made. For example, it has been assumed that perennial crops generally require very deep soils, that dryland rabi and kharif crops need deep or very deep soils, but that transplanted rice is much less affected by soil depth. Very hard topsoils are unfavourable for dryland rabi and kharif crops but they do not adversely affect most perennial crops. The limitations provided by each land factor class for specified land use types, individual crops and kind of management are described in Tables 8A and 8B in Chapter 8.

A brief discussion follows of each land factor and its relation to soil suitability for the eight land use types under traditional management, without and with irrigation. Individual crops are not discussed in detail, apart from indicating a few special features. For example, since millet requires less moisture than wheat, and rabi cotton requires more, an 'm3' rating - low available moisture holding capacity - has been rated as a slight, severe and very severe limitation for millet, wheat and rabi cotton respectively under traditional management without irrigation. If irrigation water is available, the same rating, i.e., 'm3' , does not present a limitation for millet, and carries only a moderate limitation for wheat and rabi cotton. Similarly, a soil with an 'i1' rating is suited for all types of transplanted aman, but an 'i2' rating - shallow flooding - makes HYV aman unsuitable and only allows local varieties to be grown.

### 5.1 Soil permeability

Dryland rabi crops. These crops are grown during the dry season, generally between October and March. Throughout Bangladesh, the average rainfall is low during this period, although October and March/April occasionally receive heavy post-monsoon and pre-monsoon showers respectively.

Under traditional management without irrigation, moderate and rapid permeabilities are not considered as limitations. However, early or late rabi crops could

be damaged by temporary waterlogging of slowly permeable soils, which has been interpreted as a slight limitation. Under traditional management with irrigation, similar considerations apply but, in addition, the rather inefficient irrigation techniques must be taken into account. On rapidly permeable soils, considerable amounts of water will penetrate below the root zone, which is considered as a slight limitation; also, water-logging will frequently occur on slowly permeable soils, which is considered as a moderate limitation. Moderately permeable soils are favoured and considered to be without limitation.

Boro. Under traditional management without irrigation, this crop generally is transplanted in December in permanently wet basins. Permeability as such is somewhat irrelevant, therefore. Nevertheless, rapidly permeable soils could, eventually, dry out earlier than other soils and the boro might suffer occasional moisture stress. This has been interpreted as a limitation, while moderately and slowly permeable soils are considered to have slight and no limitations respectively.

When irrigation water is available, soils with rapid permeability should not be used for boro unless they are very poorly drained, and they have been assigned a very severe limitation. Moderate permeabilities are considered a slight limitation, but slow permeabilities are favoured and do not present a limitation.

Broadcast wetland kharif crops. These are generally sown mx in the pre-monsoon period between mid-March and early-May. Harvesting takes place between mid-July and mid-September, i.e., in the rainy season, except for broadcast aman which is harvested in October-December. No differentiation has been made between limitations for the two kinds of management. In the case of rapidly permeable soils, both the pre-monsoon rainfall and irrigation water are somewhat ineffective, which is interpreted as a slight limitation. Young seedlings can be damaged by standing surface water on slowly permeable soils after rainfall or irrigation, which is also seen as a slight limitation. Moderately permeable soils do not present a limitation.

Transplanted aus. When no irrigation water is available, this crop is transplanted from April to June, depending on when the rains start. It is harvested

from late-July to September. For good crop performance, water must be ponded on the land surface before transplantation and must remain there throughout the growing season. Rapidly permeable soils are difficult to puddle, which is considered a moderate limitation. Moderately permeable soils provide a slight limitation, while no limitation is recognized for slowly permeable soils.

When irrigation water is available, the aus is transplanted in March-April and, depending on the area, irrigation may be required for one to three months. Rapid permeabilities, causing low irrigation efficiencies, are considered a severe limitation and moderate permeabilities a slight limitation. The crop does best with slow permeabilities which, therefore, do not carry a limitation.

Dryland kharif crops. These crops are grown during the monsoon season, between April and September. Heavy rainfall normally occurs during most of this period, and only well to moderately well drained soils are suited for these crops. Without irrigation water available, rapid permeability provides no limitation, but moderately and slowly permeable soils carry slight and severe limitations respectively. When irrigation water is available to be used during dry spells, slowly permeable soils become easily waterlogged, which is seen as a moderate limitation. A slight limitation and no limitation have been assigned respectively to moderately and rapidly permeable soils.

Transplanted aman. Under traditional management, this crop is transplanted from July to September and harvested in November-December. When no irrigation water is available, soils receive similar limitations as in the case of transplanted aus, i.e., rapidly, moderately and slowly permeable soils receive a moderate, slight and no limitation respectively. When irrigation water is available, some supplementary irrigation will often be required during the later stages of the growing season. Rapidly permeable soils are inefficient in water use and have been given a severe limitation. Moderately permeable soils use water less inefficiently and they can also be puddled, so they carry only a slight limitation. No problems exist in the case of slowly permeable soils.

Perennial crops. These crops occupy the land for an annual period or longer. When no irrigation water is available, they survive on available moisture stored in

the root zone during the dry season. Movement of capillary moisture is slow in slowly permeable soils, which is considered a slight limitation. No limitations have been recognized in moderately and rapidly permeable soils. With irrigation, slowly permeable soils could easily become waterlogged - a moderate limitation - while moderately and rapidly permeable soils carry a slight limitation.

5.2 Effective soil depth

Dryland rabi crops. For these crops, and also for all other land use types, no differentiation needs to be made between the with irrigation and without irrigation situations. Deep and friable soils are without limitation; deep and firm soils have a slight limitation; deep and very firm soils, shallow, friable soils and soils with a strongly developed ploughpan have all been assigned a moderate limitation; while very shallow soils provide a severe limitation.

Boro. This crop has a shallow root system and only the very shallow soils with less than 10 inches effective depth provide some degree of limitation, which has been rated as slight.

Broadcast wetland kharif crops. No limitation is recognized in deep, friable and firm soils, but a slight limitation is present in deep, very firm soils, in which, particularly, root development of jute will be hampered. The presence of a well-developed ploughpan has also been rated as a slight limitation. Shallow and very shallow soils have been given slight and severe limitations respectively.

Transplanted aus. The same ratings apply as for boro.

Dryland kharif crops. The same ratings apply as for dryland rabi crops.

Transplanted aman. The same ratings apply as for boro and transplanted aus, except that slight and moderate limitations have been assigned to shallow and very shallow soils respectively.

Perennial crops. These crops generally require a very deep rooting zone. Therefore, shallow and very shallow soils have been given severe and very severe limitations respectively. Deep, very firm soils carry a slight limitation, but none of the other depth classes provide a limitation.

5.3 Available moisture holding capacity

Dryland rabi crops. Under traditional management without irrigation, the only soils without moisture limitations are those that have an 'm0' rating, i.e., they have more than 16 inches (400 mm) of available moisture in the effective soil depth. In practice, this means that only some deep and friable silt loam floodplain soils are free from moisture limitations. Many soils have considerably less than 16 inches of available moisture, and irrigation is normally required to obtain high yields of dryland rabi crops. Slight, moderate, severe and very severe limitations have been assigned to consecutively drier classes.

When irrigation water is available, the crop water requirement can be fully met and there is no need for lack of moisture to have a limiting effect on yields. On the other hand, the lower the available moisture holding capacity, the higher the number of irrigations required which, under traditional management, means that irrigation efficiency decreases and temporary waterlogging could occur. Very high and high moisture holding capacities are considered free of limitation, but moderate, low and very low moisture holding capacities have been given slight, moderate and severe limitations respectively.

Boro. Moisture holding capacity as such is not really important for this crop. If no irrigation water is available, it can only be grown on sites that are permanently wet, independent of how much moisture has been stored in the soil. Similarly, when irrigation water is available, the feasibility of growing boro is determined more by the ability to puddle the soil than by its moisture holding capacity.

Broadcast wetland kharif crops. The sowing time of these crops and their early development stages depend on the first pre-monsoon showers and not so much on the amount of available moisture that is left in the soil. However, to carry the crops through dry spells during their growing period, a good soil moisture holding capacity is still necessary. Under non-irrigated conditions, no limitation is considered to exist when more than 8 inches (200 mm) of available moisture can be stored within the effective soil depth. Moderate and severe limitations have been recognized for the low and very low classes respectively. If irrigation water is available, only the very low class has been given a

slight limitation.

Transplanted aus. When no irrigation water is available, this crop will only be transplanted when there has been sufficient rainfall to puddle the soil and, under normal rainfall conditions, flooded fields can be maintained. Success of the crop will depend more on the amount of water ponded on the soil surface than on the amount of water in the soil. The low and very low classes have been given slight and moderate limitations respectively. No limitation at all is recognized when irrigation water is available.

Dryland kharif crops. Though these crops generally are sown in the pre-monsoon season, the major part of the growing period is during the monsoon season. Plants normally can obtain the required moisture from rainfall, and the available moisture holding capacity is a much less important factor than for dryland rabi crops. Nevertheless, monsoon rains can start late, dry periods can occur during the monsoon season, or the rains can finish earlier than normal. In all these cases, plants have to survive on moisture stored in the root zone. A slight limitation has been assumed to exist when moisture holding capacity is low and a moderate limitation when it is very low. When irrigation water is available, only the very low class carries a slight limitation.

Transplanted aman. During the early and middle growing stages of this crop, rainfall normally is sufficient to ensure good crop development. Whether the crop will survive when the monsoon rains finish early, or when the post-monsoon showers fail, will depend not so much on the amount of available moisture as on the amount of water ponded on the soil surface. Length and depth of inundation are, therefore, a much more important factor. If no irrigation water is available, the low and very low classes carry slight and moderate limitations respectively. No limitation at all has been recognized when irrigation water is available.

Perennial crops. Perennial crops (except pineapple and banana) generally have a very deep rooting system and are able to explore a much greater volume of soil to obtain moisture than other crops. On the other hand, their requirement is often much higher. Without irrigation water available, moderate, low and

very low classes of available moisture have been given slight, moderate and severe limitations respectively. Under irrigated conditions, only the low and very low classes carry slight and moderate limitations respectively.

5.4 Nutrient availability

Not enough information is available for a proper evaluation of the effects of nutrient availability on different land use types or on individual crops. No limitation has been recognized in soils of relatively high fertility, and a slight limitation has been assigned to all crops on relatively infertile soils. No differentiation is made between irrigated and non-irrigated conditions.

5.4 Soil reaction

The range of slightly acid to slightly alkaline soils is considered favourable for all land use types. Moderately alkaline soils offer a slight limitation, as do medium and strongly acid soils, except for perennial crops, most of which also do well when the pH is between 4.5 and 5.5. Very strongly acid and very strongly alkaline soils represent severe limitations for all kinds of land use. No differentiation is made between irrigated and non-irrigated conditions.

5.6 Soil salinity

Soil salinity ratings generally refer to conditions in the dry season. Except on land where tidal flooding with salt water occurs throughout the year, soils become non-saline in the rainy season under the influence of heavy rainfall and/or flooding with fresh water. Kharif crops are affected only in areas where the rains start late and end early. Irrigation water is not available in many parts of the saline zone, so soils in such areas have been given the same rating as for non-irrigated conditions. Where sweet water is available for irrigation, the soils should be considered non-saline and the salinity rating ignored.

Dryland rabi crops. No limitation is present in non-saline soils with an ECe of less than 2 millimhos. Vegetable crops, in particular, already suffer yield reductions under slightly saline conditions, and an ECe of between 2 and 4

millimhos is considered a slight limitation. Moderate, severe and very severe limitations have been assigned to consecutively more saline soils.

Boro. Moderate, severe and very severe limitations have been assigned to weakly, moderately and strongly saline soils respectively.

Broadcast wetland kharif crops. These crops are generally sown during the period when soil salinity is high. Sowing takes place after the first pre-monsoon rains have leached the topsoil, but both rice and jute are very sensitive to salinity at germination and during the early growth stages. Weakly saline soils have been given a slight limitation, and moderately and strongly saline soils severe and very severe limitations respectively.

Transplanted aus. Under rainfed conditions, aus will only be transplanted when the topsoil has ~~been~~ mx lost most or all of its dry season salts. Most likely, a soil that was rated as slightly saline in the dry season will have become non-saline or very weakly saline by the time of transplanting. Therefore, weakly saline soils carry only a slight limitation; moderately and strongly saline soils have severe and very severe limitations respectively.

Dryland kharif crops. These crops are grown during the monsoon season, at which time the dry season salinity will have decreased considerably. Consequently, weakly, moderately and strongly saline soils have been given slight, moderate and severe limitations respectively.

Transplanted aman. At the time when this crop is transplanted, the dry season salinity will normally have been significantly reduced. However, when the rains end earlier than normal, salinity may adversely affect the crop at the time of heading or grain filling. Accordingly, slight, moderate and severe limitations have been assigned respectively to weakly, moderately and strongly saline soils.

Perennial crops. The same ratings generally apply as for dryland rabi crops.

5.7 Topsoil consistence and bearing capacity

Dryland rabi crops. To ensure good topsoil tilth, aeration and root development, a soft friable topsoil is required. Topsoils that become hard to very hard on drying out are considered to have a slight limitation, and extremely hard topsoils to have a moderate limitation. Peat soils carry a slight limitation. No differentiation needs to be made between irrigated and non-irrigated conditions.

Boro. Topsoil consistencies are not very relevant for transplanted rice crops which are grown in puddled, wet topsoils. Nevertheless, very hard consistencies can adversely affect land preparation, or growth is reduced when the soil dries out into very to extremely hard clods. This situation is considered as a slight limitation. Thick organic surface layers are considered a severe limitation since such soils are normally wet and offer a poor foothold for the rice plant, making it liable to lodging. In addition, trafficability is seriously reduced.

Broadcast wetland kharif crops. Particularly during their establishment and early growing periods, these crops require friable topsoils for seed germination and seedling growth. Slight, moderate and severe limitations have been recognized for increasingly heavier consistencies.

Transplanted aus. The same considerations apply as for boro.

Dryland kharif crops. The same ratings apply as for dryland rabi crops.

Transplanted aman. The same ratings apply as for boro and transplanted aus.

Perennial crops. Unfavourable topsoil conditions affect these crops to a much lesser degree than they do the dryland crops. Tree crops generally are not adversely affected, but much crops as pineapples and bananas may be to variable extents. Therefore, very hard topsoils have been given a slight limitation. Thick peaty topsoils are considered a severe limitation for these crops.

5.8 Drainage

Drainage relates to the rate at which excess water is removed from the root-zone. Only well drained soils are without a drainage limitation throughout

the year. Moderately well drained and imperfectly drained soils have limitations for sensitive dryland crops in the kharif season, and poorly drained and very poorly drained soils cannot be used for dryland crops in this season at all. On the other hand, poor drainage is an asset for wetland crops.

In rating drainage, care has to be taken to differentiate limitations caused by permeability, inundation and flood hazard from the drainage factor so as to avoid double counting of limitations.

Dryland rabi crops. Well drained soils have no limitations for any crops. Early rabi crops (tobacco, cotton, vegetables) are given slight or moderate limitations on moderately well drained soils, and increasingly severe limitations on imperfectly and poorly drained soils. Other rabi crops are without limitations on moderately well and imperfectly drained soils, and only crops which require early sowing for high yields have been given a slight limitation on early draining poorly drained soils. Late draining, poorly drained soils have generally been given a severe or very severe rating, and very poorly drained soils carry a very severe rating for all crops. Millet and chilli, which can be planted as late as February, are not given any limitation on poorly drained soils (so long as they drain before February).

Boro. In the case of traditional management without irrigation, only very poorly drained soils are suitable for boro cultivation. All other drainage classes carry a very severe limitation. None-the-less, very poorly drained soils have still been rated as having a severe limitation since only the low yielding local boro varieties can be grown and HYVs are not possible. When irrigation water is available, well drained and moderately well drained soils have been given severe and moderate limitations respectively. Other classes have been given a 'no limitation' except the very poorly drained class in which toxicity problems can arise.

Broadcast wetland kharif crops. All drainage conditions, except late draining poorly drained and very poorly drained, are considered suitable for these crops. Soils that remain wet throughout most or all of the year are considered poorly suited or unsuited due to lack of opportunities for land preparation and toxicity problems.

Transplanted aus. Severe, moderate and slight limitations have been assigned to well, moderately well, and imperfectly drained soils respectively. Poorly drained soils carry no limitation, but very poorly drained soils are given a moderate limitation because of the risk of toxicity problems in permanently wet soils.

Dryland kharif crops. Only the well drained soils are fully suited. By definition, moderately well drained soils are saturated for a number of days after heavy rainfall, which is interpreted as a moderate limitation. Imperfectly drained soils are saturated for a number of weeks, which is seen as a severe limitation. Poorly and very poorly drained soils are not suited to these crops.

Transplanted aman. The same ratings apply as for transplanted aus.

Perennial crops. The same ratings apply as for dryland kharif crops.

5.9 Depth of inundation

Inundation is a seasonal phenomenon and only occurs in the rainy season. Therefore, it is important to consider the inundation situation during the normal growing period of each land use type and crop; for example, it should be realised that boro can grow very well on a soil that received an i5 - very deeply inundated - rating, so long as inundation does not begin before the normal time of boro harvesting: i.e., April-May for local varieties; May-June for HYVs.

Dryland rabi crops. Since soils are not normally inundated during the rabi season, all inundation classes have been considered to be without limitation. The limitation caused by inundation in the dry season is captured in the very poorly drained class under Drainage (4.8).

Broadcast wetland kharif crops. Under traditional management without irrigation, no inundation and very shallow inundation are considered the most favourable conditions, particularly for broadcast aus and jute. Shallow inundation is considered a slight limitation. Moderately deep inundation restricts the cultivation of jute, is a serious limitation for broadcast aus, but does not hamper broadcast aman: overall, this situation is rated as a moderate limitation. Deep inundation prevents broadcast aus and jute from being grown. Only broadcast aman can be grown: this

situation has been rated as a severe limitation. Very deep inundation is considered a very severe limitation and cropping is generally not possible. Similar limitations apply for traditional management with irrigation.

Transplanted aus. The most favourable situations are no inundation and very shallow inundation, when all aus varieties can be grown. Shallow inundation (up to 3 feet) prevents the cultivation of HYVs, but LVs and LIVs can still be grown: a moderate limitation has been assigned. Flooding deeper than 3 feet is considered a very severe limitation. Similar limitations apply for non-irrigated and irrigated conditions.

Dryland kharif crops. Only land that is free from inundation is suited for these crops; all other classes have been given a very severe limitation.

Transplanted aman: The same ratings apply as for transplanted aus.

Perennial crops. The same ratings apply as for dryland kharif crops.

5.10 Flood hazard

Flood hazards exist during the pre-monsoon and monsoon seasons. In coastal areas, cyclones can also occur in the post-monsoon season. Therefore, dryland rabi crops are not normally affected and only the ~~xf@x~~ 'f4' class has been given a moderate limitation. In the case of boro, the longer maturing varieties could be affected and the moderate, severe and very severe hazard classes have been considered as slight, moderate and severe limitations respectively. Similar ratings have been applied in the case of transplanted aman. For all other land use types and crops, the 'no hazard' class is without limitation, and slight, moderate, severe and very severe limitations have been assigned to increasing frequencies of hazard.

5.11 Slope

Dryland rabi crops. Ease of land management and erosion hazard are the criteria to be considered. Since rainfall is normally low during the rabi growing period, soil erosion is somewhat irrelevant. On the other hand, when keeping in mind sustained cropping over a long period of time, the cultivation of short-term annual crops in a monsoon climate leaves the soils without any substantial cover during the rainy season. Therefore, only level land is without limitation; gently sloping

and sloping land have been given moderate and severe limitations respectively, while steeper slopes are considered unsuited. Under traditional management with irrigation, level land is free from limitations, gently sloping land provides a severe limitation and steeper slopes are unsuited : (sprinkler systems which might be used under modern commercial management would need to be rated separately).

Boro. Only level land is favoured. Gently sloping land carries a severe limitation. All other slope classes have been given a very severe limitation. Note that terraced fields would be treated as level land.

Broadcast wetland kharif crops. The same ratings apply as for dryland rabi crops.

Transplanted aus. The same ratings apply as for boro.

Dryland kharif crops. Since these crops are grown during the monsoon season, the erosion hazard is of great importance. Level to nearly level land has no limitation, gently sloping land has a moderate limitation, while land with slopes steeper than 8 percent has been given a very severe limitation and is considered unsuited. With irrigation, ratings are similar, except that gently sloping land provides a severe limitation.

Transplanted aman. The same ratings apply as for transplanted aus.

Perennial crops. Most perennial crops, particularly tree crops, provide a good ground cover which protects the soil effectively against erosion. Slopes of up to 8 percent do not provide a limitation, while slight, moderate, severe and very severe limitations have been assigned to increasingly steeper slope classes. With irrigation, all land steeper than 8 percent has been considered unsuited, while slopes between 3 and 8 percent have been assigned a severe limitation.

5.12 Climate

Dryland rabi crops. In climates with a long dry season, rabi crops have been given a slight limitation. When irrigation water is available, climate (meaning rainfall distribution) is not a limitation.

Boro. The early start of the rains in eastern Districts, coming before boro is harvested, provides a slight limitation (mainly for HYVs, which are harvested later than local varieties).

Broadcast wetland kharif crops. Areas with a relatively long dry season have been assigned a moderate limitation since the sowing time of these crops is often delayed by drought, interfering with optimum rotations. Wetter central and eastern areas have been given a slight limitation because heavy rainfall, high humidity and cloudiness reduce yields below optimum.

Transplanted aus. It has been considered that, under traditional management without irrigation, the present trend is for farmers to go for transplanted aus rather than for transplanted aman. In climates with a long dry season, transplanting of the aus will be late and will prevent the cultivation of a second, high-yielding, transplanted rice crop. Climates with a short dry season do not carry any limitation, nor do those with ~~irrigation~~ medium dry seasons for local varieties and LIVs. Climates with a long dry season have been given a moderate limitation for local varieties and LIVs. HYVs have been given slight and moderate limitations respectively for medium and long dry season climates. With irrigation, there is no limitation, except in the wetter east.

Dryland kharif crops. Since these crops are grown during the monsoon season, they are not affected by rainfall distribution as such. However, the heavy rainfall, cloudiness and high humidity provide management problems and limit yields: severe, moderate and slight limitations have been assigned respectively to areas with long, medium and short rainy seasons.

Transplanted aman. Two cases need to be considered:

a) transplanted aman as a single crop, without consideration of its place in a crop rotation (symbol T);

b) transplanted aman as a component of a kharif crop rotation, especially t.aus-t.aman (symbol U).

In the case of T, no, slight and moderate limitations have been ascribed to climates where the rainy season is, respectively, more than 6 months, 5-6 months and less than 5 months.

In the case of U, slight, moderate and severe limitations have been given to climates with rainy seasons more than 6 months, 5-6 months and less than 5 months respectively.

With irrigation, there is no climatic limitation in either case.

Perennial crops. A slight limitation has been assigned to olimates with a long dry season.

## 6. EXAMPLE OF HOW TO CALCULATE LAND FACTOR RATINGS

In this chapter, the method of calculating land factor ratings is demonstrated by working through a particular example. First, the representative soil profile description for the selected soil, Farabari series, is given, extracted from the Appendix section of the Thakurgaon soil survey report (3). Then, each of the land factors is considered in relation to the definitions given in Chapter 6 in order to demonstrate how individual land factor ratings are arrived at. The resulting land factor formula, comprising the ratings for each of the 12 land factors considered, is then ready for assessing the suitability of individual land use types or crops, as described in Chapter 8.

Series : Farabari (Thakurgaon soil survey report).

Physiography : Very gently sloping piedmont ridge

Land use : Aus-transplanted aman

Drainage : Poorly drained, seasonally flooded up to 1 foot deep for about 2 months. Remains unsaturated for about 6 months in the dry season.

Ap1g 0-5 inches; olive grey (5Y5/2) moist to grey (5Y6/1) dry with few fine and medium distinct yellowish brown mottles; silt loam; massive, breaking into coarse and medium angular clods; friable, slightly sticky, slightly plastic; common fine and very fine tubular pores; abrupt smooth boundary; pH 5.6;

Ap2g 5-7 inches; olive grey (5Y5/2) moist with common fine distinct yellowish brown mottles; silt loam; massive; firm, slightly sticky, slightly plastic; abrupt smooth boundary; pH (6.5);

B21 7-17 inches; dark greyish brown (2.5Y4/2) moist with few fine faint dark yellowish brown mottles; clay loam; strong coarse prismatic; firm, sticky, plastic; continuous moderately thick grey gleyans along vertical ped faces; many fine and a few medium tubular pores; clear smooth boundary; pH 6.5;

B22 17-28 inches; dark greyish brown (2.5Y4/2) moist, common fine faint dark yellowish brown mottles; silt loam; strong coarse prismatic; friable, sticky, plastic; continuous moderately thick grey gleyans along vertical ped faces; many fine and few medium tubular pores; clear smooth boundary; pH 6.8;

B3 28-42 inches; dark greyish brown (2.5Y4/2) moist, common fine faint dark yellowish brown mottles; silt loam; moderate coarse prismatic; friable, sticky, plastic; broken thin grey gleyans along vertical ped faces; many fine and few medium tubular pores; abrupt smooth boundary; pH 6.3;

C 42-55 inches; light brownish grey (2.5Y6/2) moist; loam; massive; very friable, slightly sticky, slightly plastic; pH 6.3.

Note: pH figures given in brackets were recorded in the field using a Hellige-Truog test kit.

These soils are flooded by rainwater up to 0.5-3 feet deep for 1-3 months in the monsoon season. They are mainly used for aus followed by transplanted aman. Sometimes, millet or jute replaces aus.

Thickness of the solum ranges from 20 to 45 inches. Topsoil varies from grey to brownish grey, sometimes dark greyish brown, and from loam to clay loam. In the B horizon, texture is usually clay loam, occasionally it is silt loam; mottles may be few or common, sometimes many; structure may be moderate or strong. Buried, dark-coloured topsoils occur in some profiles below about 25 inches.

a. Permeability

Laboratory data are not available and the table must be used. A ploughpan (Ap2 horizon) is present; therefore, only the profile between 7 and 50 inches should be considered. The alluvium is of non-Gangetic origin, medium and moderately fine textured, relatively well structured and porous. On this basis, permeability should be rated as 'moderate' and the soil be rated 'p1'.

b. Effective soil depth

A ploughpan is present, but consistence is only described as firm; therefore, a 'd5' rating does not apply. Calculation of the effective depth is as follows:-

| | | |
|---|---|---|
| 0-5 in. | : coefficient of 1 | 1 x 5 = 5 |
| 5-7 in. | : coefficient of 0.75 | 0.75 x 2 = 1.5 |
| 7-17 in. | : coefficient of 0.75 | 0.75 x10 = 7.5 |
| 17-28 in. | : coefficient of 1; friable and plastic are contradictory, but silt loam texture indicates 1 and not 0.75 | 1 x11 = 11 |
| 28-42 in. | : as 17-28 | 1 x14 = 14 |
| 42-50 in. | : coefficient of 1 | 1 x 8 = 8 |
| | | Total: 47 inches |

The soils falls within the 36-48 inches class, so is given a 'd1' rating.

c. Available moisture holding capacity

Parent material is Old Himalayan Piedmont alluvium, so the figures in column 1 of the table should be used, viz.-

| | | |
|---|---|---|
| 0-5 in. | : silt loam | 5 x 0.32 = 1.60 |
| 5-7 in. | : silt loam | 2 x 0.32 = 0.64 |
| 7-17 in. | : clay loam | 10 x 0.26 = 2.60 |
| 17-28 in. | : silt loam | 11 x 0.32 = 3.52 |
| 28-42 in. | : silt loam | 14 x 0.32 = 4.48 |
| 42-47 in. | : loam | 5 x 0.30 = 1.50 |
| | | Total =14.34 |

This total falls within the class 12-16 inches, so an 'm1' rating is given. Note that a depth of 47 inches, corresponding to the effective soil depth, and not 50 inches has been used as the lower boundary for the calculation.

d. Nutrient availability

Farabari series is developed in medium to moderately fine textured Old Himalayan Piedmont alluvium, there are no indications of ferrolysis, and the series belongs to the Haplaquepts. Therefore, the nutrient availability rating is 'n0'.

e. Soil reaction

All horizons except the Ap2g show the laboratory reaction. These values should

be increased by 0.5 and 1.0 for topsoil and subsoil/substratum respectively, viz.-

| | |
|---|---|
| 0-5 in. : 5.6 + 0.5 = 6.1 | 5 x 6.1 = 30.5 |
| 5-7 in. : | 2 x 6.5 = 13.0 |
| | 43.5 |

$$(43.5 \div 7) \times 2 = 12.42$$

| | |
|---|---|
| 7-17 in. : 6.5 + 1.0 = 7.5 | 10 x 7.5 = 75.0 |
| 17-24 in. : 6.8 + 1.0 = 7.8 | 7 x 7.8 = 54.6 |
| | 129.6 |

$$(129.6 \div 17) = 7.62$$

Soil reaction is : $(12.42 + 7.62) \div 3 = 6.68$. It falls within the 5.6-7.3 class, so is given an 'a0' rating.

f. Soil salinity

From the chemical analyses - ECe x $10^3$ is 0.45 - it is clear that the series is non-saline throughout and so should be rated 's0'.

g. Topsoil consistence

The series has a mineral surface soil with texture ranging from loam to clay loam; topsoil consistence has been described as friable and slightly sticky and slightly plastic. Tillage problems are not expected, therefore. The rating is 't0'.

h. Drainage

Environmental characteristics indicate that all soils are seasonally flooded and that flooding lasts for about 1 to 3 months. This indicates that the soils are poorly drained but free from flooding well before mid-November. On these grounds, the series is rated 'w3'.

i. Depth of inundation

It is stated in the environmental characteristics that the series is flooded by rainwater up to 0.5 to 3 feet deep. Some soils, therefore, will be flooded less than 1 foot deep, others between 1 and 3 feet. Since both 'i1' and 'i2' ratings are possible, the series must be rated 'i6'.

Applying the 25/75 percent distribution formula described in Chapter 4, Section 9, paragraph (v), if the series occupies 30 percent of a soil association

covering 100 square miles, 'i1' soils would cover an area of 100 x 0.30 x 0.25 square miles, and 'i2' soils 100 x 0.30 x 0.75 square miles : i.e., 7.5 and 22.5 square miles respectively.

j. Flood hazard

Both the environmental characteristics, the phase designations and the physiographic position indicate that Farabari series is not subject to any flood hazards. Therefore, it should be rated 'f0'.

k. Slope

The series is located in nearly level areas ~~in~~ on lower slopes of ridges. Obviously, it should be rated 'e0'.

l. Climate

The series is located in the Thakurgaon District. The climate there has a relatively long dry season and soil is rated 'c2' (except for t.aman following aus, where it is rated 'c3').

m. Land factor formula

The Farabari series, as described in the Thakurgaon report, has the following land factor formula :-

p1 d1 m1 n0 a0 s0 t0 w3 i6 f0 e0 c2. This can be 'translated' as :-

p1 : moderate permeability

d1 : deep with friable to firm consistence

m1 : high available moisture holding capacity

n0 : relatively high nutrient availability

a0 : medium acid to neutral

s0 : non-saline

t0 : no tillage problems

w3 : poorly drained but not slow draining

i6 : very shallowly and shallowly flooded

f0 : free from flood hazards

e0 : level and nearly level position

c2 : short rainy season, long dry season

## 7. SOIL-CROP SUITABILITY RATING

In order to determine the suitability of a soil for any of the land use types or individual crops, the total number and degree of limitations, as provided by the land factor classes, must be determined. Five degrees of limitation have been recognized :-

0 - no limitation, representing the most favourable condition;

1 - slight limitation;

2 - moderate limitation;

3 - severe limitation;

4 - very severe limitation; the soil is unsuited for the land use type or crop under consideration at the specified level of management.

The degrees of limitation represented by individual land factor classes for the land use types and a large number of individual crops are shown in Tables 8A and 8B. Rather than let the suitability depend on the most severe limitation - independent of the number of limitations - the latter has also been taken into account. This means that, for example, a soil with five or six slight limitations will receive a lower suitability rating than a soil with only one moderate limitation. On the other hand, the suitability of a soil will never be higher than its most severe limitation: i.e., a soil with one severe limitation will never be rated as moderately or highly suited. The relationship between soil suitability and the number and degree of limitations is set out in Table 7.1

Five soil suitability classes have been distinguished, viz.-

S1 - high suitability: the soil has no significant limitations and, within the constraints of the kind of management specified, has a high potential productivity.

S2 - moderate suitability: the soil has a number of slight and/or moderate limitations that render it potentially less productive than soils in class S1.

S3 - low suitability: the soil has a number of slight, moderate and/or severe limitations and its potential productivity is significantly less than soils in class S1. Within the constraints of the specified management, the productivity of the soil can be improved by relatively simple measures.

S4 - very low suitability: the soil has a number of slight, moderate and severe limitations and its potential productivity is very low. Within the constraints of the specified management, the productivity of the soil is difficult to improve.

N - no suitability: the soil has a large number of limitations, usually including one or more very severe limitations. The potential productivity is very low and the soil generally is not used for the land use type or crop under consideration. Within the constraints of the specified kind of management, productivity cannot be improved.

In order to demonstrate how to determine the soil suitability classes, an example is worked through below. The example is that of Farabari series, Medium Highland phase, used in Chapter 6 for demonstrating how to determine land factor classes. In section m of that chapter, the land factor formula for that soil was shown to be:

p1, d1, m1, n0, a0, s0, t0, w3, i6, f0, e0, c2.

The relationship between those land factor classes and limitations for land use types and individual crops is shown in Tables 8A.1-8 for non-irrigated crops and in Tables 8B.1-8 for irrigated crops. The procedure is as follows.-

1. For the selected land use type or crop, turn to the appropriate table of Table 8A or 8B. For our example, we will take rabi dryland crops under non-irrigated conditions: i.e., in Table 8A.1, the column under 'R' in each block under the relevant limitation number.

2. For the permeability land factor, the class is p1. Under limitation column number 1, the first line 'p' has 0 under R. In other words, permeability class 1 does not provide any limitation for dryland rabi crops under non-irrigated conditions. Write 0 against the symbol p1 on a work-sheet.

3. Next, follow the same procedure for the soil depth land factor. The class given is d1. Under the limitation column number 1, the second line 'd' has the number 1 shown under R. That means that soil depth provides a slight limitation for dryland rabi crops without irrigation. Record 1 against d1 on a work-sheet.

4. Follow the same procedure successively for the remaining land factors m to c, recording the degree of limitation for each factor in turn.

5. In the case of i (inundation), i6 indicates that i1 and i2 ratings have to be determined separately, as instructed in Chapter 4, section 9(v). In this case, the ratings are as follows:-

   - i1 (very shallowly flooded land): 0 (= no limitation).
   - i2 (shallowly flooded land) : 0 ( ditto ).

   Record these ratings against the symbol i6, as shown below.

6. When all the limitations have been assessed, the list will appear thus :

| Land class | Limitation | |
|---|---|---|
| p1 | - 0 | |
| d1 | - 1 | |
| m1 | - 1 | |
| n0 | - 0 | |
| a0 | - 0 | |
| s0 | - 0 | |
| t0 | - 0 | |
| w3 | - 1 | |
| i6-i1 | - 0 | i2-0 |
| f0 | - 0 | |
| e0 | - 0 | |
| c2 | - 1 | |

7. Add the number of occurrences of each limitation rating and enter into a table below the list, as follows:-

   Limitation class 4 x 0
   3 x 0
   2 x 0
   1 x 4 (for both i1 and i2)
   0 x 8

8. Refer to Table 7.1. A soil with four 1 ratings appears against 'Moderate suitability (S2)'. Therefore, Farabari series, Medium Highland phase, is rated in suitability class S2 for dryland rabi crops without irrigation.

9. Follow the same procedure for determining the suitability for other land use types or crops.

10. In the case of transplanted aman, this crop has to be considered both as a single crop and as a component of the common aus-t.aman rotation.

- As a single crop (T), the climatic rating c2 has a limitation 2: i.e., Table 8A.1, line c, limitation column 2, crop T.
- Following aus, the crop (U) would have a limitation 3: i.e., Table 8A.1, line 'c for U', limitation column 2, crop T.

11. The full list of limitations for transplanted aman without irrigation would accordingly be:

| | T | | U | |
|---|---|---|---|---|
| | p1 - 1 | | - 1 | |
| | d1 - 0 | | - 0 | |
| | m1 - 0 | | - 0 | |
| | m0 - 0 | | - 0 | |
| | a0 - 0 | | - 0 | |
| | s0 - 0 | | - 0 | |
| | t0 - 0 | | - 0 | |
| | w3 - 0 | | - 0 | |
| | i6-i1 - 0 | i2-2 | i1- 0 | i2-2 |
| | f0 - 0 | | - 0 | |
| | e0 - 0 | | - 0 | |
| | c2 - 2 | | - 3 | |
| c for U | | | | |

12. The numbers of occurrences of each limitation rating are thus :

| | T(i1) | T(i2) | U(i1) | U(i2) |
|---|---|---|---|---|
| Limitation class | 4 x 0 | x 0 | x 0 | x 0 |
| | 3 x 0 | x 0 | x 1 | x 1 |
| | 2 x 1 | x 2 | x 0 | x 1 |
| | 1 x 1 | x 1 | x 1 | x 1 |
| | 0 x10 | x 9 | x10 | x 9 |

13. Referring to Table 7.1, these limitations would provide the following suitability classes :-

- T(i1): 2 x 1, 1 x 1 = S2
- T(i2): 2 x 2, 1 x 1 = S3
- U(i1): 3 x 1, 1 x 1 = S3
- U(i2): 3 x 1, 2 x 1, 1 x 1 = S3

It is emphasized again that, at present, the soil suitability ratings cannot be related directly to specific crop yield classes. However, within each specified level of management, the range from S1 to N indicates a decrease in soil suitability, with the highest yield potential expected to exist in soils rated as S1. The range in yields under traditional management without irrigation is expected to be narrower than in the case of management with irrigation. Therefore, S1 ratings under traditional management with irrigation would normally be expected to indicate a higher potential yield than S1 ratings under traditional management without irrigation.

Table 7.1 : Relationship between land use suitability and number and degree of limitations

| Soil suitability | number and degree of limitations |
|---|---|
| high suitability (S1) | all 0<br>one 1, rest 0<br>two 1, rest 0 |
| moderate suitability (S2) | three 1, rest 0<br>four 1 , rest 0<br>one 2, rest 0<br>one 2, one 1, rest 0<br>one 2, two 1, rest 0<br>two 2, rest 0 |
| low suitability (S3) | five 1, rest 0<br>six 1, rest 0<br>one 2, three 1, rest 0<br>one 2, four 1, rest 0<br>two 2, one 1, rest 0<br>two 2, two 1, rest 0<br>three 2, rest 0<br>one 3, rest 0<br>one 3, one 1, rest 0<br>one 3, two 1, rest 0<br>one 3, one 2, rest 0<br>one 3, one 2, one 1, rest 0 |
| very low suitability (S4) | seven 1, rest 0<br>eight 1, rest 0<br>nine 1, rest 0<br>one 2, five 1, rest 0<br>one 2, six 1, rest 0<br>two 2, three 1, rest 0<br>two 2, four 1, rest 0<br>three 2, one 1, rest 0<br>three 2, two 1, rest 0<br>four 2, rest 0<br>one 3, three 1, rest 0<br>one 3, four 1, rest 0<br>one 3, one 2, two 1, rest 0<br>one 3, one 2, three 1, rest 0<br>one 3, one 2, four 1, rest 0<br>one 3, two 2, rest 0<br>one 3, two 2, one 1, rest 0<br>two 3, rest 0<br>two 3, one 1, rest 0 |
| no suitability (N) | all other combinations |

## 8. DEGREES OF LIMITATION

Degrees of limitation provided by individual land factor classes for specific land use types and crops have been set out in Table 8A for non-irrigated conditions and in ~~the~~ Table 8B for irrigated conditions. While the land factor classes are rather fixed and difficult to change, the limitations can be changed quite easily and should be changed if and when new information about particular crops comes to hand. As pointed out earlier, limitations have been assessed subjectively and, unfortunately, cannot at this stage be expressed in terms of yield reduction. When considering limitations for soil suitability assessments, the procedure set out in Chapter 7 should be followed in most cases. However, there are a number of important exceptions which should be applied whenever relevant. These are indicated below.

a) When evaluating soil suitability for transplanted rice land use types and individual crops (i.e., boro, transplanted aus and transplanted aman), all the permeability (p) classes should be given a '0' limitation when the soil has a 'd5' rating and is located outside the Ganges floodplain physiographic unit.

b) If the soil has a 'w5' rating, all the permeability classes (p) should be given a '0' limitation for all land use types and individual crops.

c) When evaluating soils with an 'i6' rating, it is necessary to consider both the limitations of the 'i1' and 'i2' ratings, as explained in Chapter 4. When calculating areas of suitability classes, the area occupied by a soil rated as 'i6' is split in such a way that 25% is assigned to the 'i1' rating and 75% to the 'i2' rating.

d) When evaluating soils that have a rating combination of 'w2' and 'i1' for transplanted aus and aman under traditional management without irrigation, the suitability rating of S1 should be increased by one unit to S2, except when the soil has a 'd5' rating.

e) When evaluating soil suitability under traditional management with irrigation, the suitability rating of soils with an irregular relief, man-made, narrow extent or terraced phase should be increased by one unit : i.e., S1 becomes S2; S2 becomes S3; etc. Soils that have been placed in the broadly and closely dissected phases will have their suitability increased by 2 units: i.e., S1 becomes S3; S2 becomes S4; etc. Obviously, double counting should be avoided in cases where, for example, terraced phase soils occur on a broadly dissected landscape.

Table 8A.1: Relationship between land factor classes and limitations for land use types under traditional management without irrigation

| Land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | land use type RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP |
| | limitations | | | | | |
| p | 0222020 | 0101110 | 1010301 | | | |
| d | 0000000 | 1000000 | 2010101 | 3010213 | 4231324 | 2010200 |
| m | 0000000 | 1000000 | 2000001 | 3021112 | 4232223 | |
| n | 0000000 | 1111111 | | | | |
| a | 0000000 | 1111011 | 1111110 | 2222222 | 2222222 | |
| s | 0000000 | 1000001 | 2211112 | 3333223 | 4444334 | |
| t | 0000000 | 1010100 | 2121211 | 1333133 | | |
| w | 0403030 | 0402221 | 0401313 | 1400404 | 3420404 | 4342424 |
| i | 0000000 | 0000404 | 0012424 | 0024444 | 0044444 | 0044444 |
| f | 0000000 | 0010101 | 0011212 | 0122323 | 2233434 | |
| e | 0000000 | 2423230 | 3434441 | 4444442 | 4444443 | 4444444 |
| c (c for U) | 0111301 (1) | 0011212 (2) | 1022123 (3) | | | |

Code for generalized land use types :

R : dryland rabi crops
B : boro
W : broadcast wetland kharif crops
A : transplanted aus
K : dryland kharif crops
T : transplanted aman
P : perennial crops and long-term annual crops

Code for limitations :

'0' , no limitation
'1' , slight limitation
'2' , moderate limitation
'3' , severe limitation
'4' , very severe limitation

'c for U' = climate rating for transplanted aman in transplanted aus-transplanted aman rotation.

Table 8A.2: Relationship between land factor classes and limitations for individual dryland rabi crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | dryland rabi crops | | | | | |
| | WhMiRsRmRc | WhMiRsRmRc | WhMiRsRmRc | WhMiRsRmRc | WhMiRsRmRc | WhMiRsRmRc |
| | limitations | | | | | |
| p | 0 0 0 0 0 | 0 0 0 0 0 | 1 1 1 1 2 | | | |
| d | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 3 3 3 3 3 | 4 4 4 4 4 | 3 3 3 3 3 |
| m | 0 0 0 0 0 | 1 0 0 1 2 | 2 0 1 2 3 | 3 1 2 3 4 | 4 2 3 4 4 | |
| n | 0 0 0 0 0 | 1 1 1 2 2 | | | | |
| a | 0 0 0 0 0 | 0 0 0 1 0 | 1 1 1 0 2 | 2 2 2 2 3 | 1 1 1 2 1 | |
| s | 0 0 0 0 0 | 1 1 1 2 1 | 1 1 2 3 1 | 3 3 3 4 2 | 4 4 4 4 3 | |
| t | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 0 2 | 0 0 0 0 3 | 1 0 1 1 4 | 3 0 3 3 4 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 1 0 0 0 | 0 2 0 0 0 | 2 3 2 2 2 | |
| e | 0 0 0 0 0 | 2 2 2 2 2 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 |
| c | 0 0 0 0 2 | 0 0 0 0 1 | 1 0 1 1 0 | | | |
| | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb |
| p | 0 0 0 0 0 | 0 0 0 0 0 | 1 1 1 2 1 | | | |
| d | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 2 2 3 2 2 | 3 4 4 4 4 | 0 2 2 2 2 |
| m | 0 0 0 0 0 | 0 0 0 0 0 | 2 1 1 1 1 | 4 2 3 3 3 | 4 3 4 4 4 | |
| n | 0 0 0 0 0 | 1 1 1 1 1 | | | | |
| a | 0 0 0 0 0 | 2 1 1 2 1 | 1 1 1 1 1 | 2 2 2 2 2 | 3 2 2 3 2 | |
| s | 0 0 0 0 0 | 2 1 0 2 0 | 3 4 2 4 3 | 4 4 4 4 4 | 4 4 4 4 4 | |
| t | 0 0 0 0 0 | 1 2 1 1 1 | 2 3 2 2 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 1 0 | 0 0 0 1 0 | 0 0 0 2 0 | 3 4 4 4 4 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 2 2 2 2 2 | |
| e | 0 0 0 0 0 | 2 2 2 2 2 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 |
| c | 0 0 0 2 0 | 0 0 0 1 0 | 1 0 0 0 0 | | | |

Code for dryland rabi crops :

Wh : wheat and barley
Mi : millet
Rs : rabi sorghum
Rm : rabi maize
Rc : rabi cotton

Po : potatoes
Rg : rabi groundnuts
Sf : sunflower
$T_o$ : tobacco
Sb : soybeans

Table 8A.2 (continued)

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | dryland rabi crops | | | | | |
| | CbTmRoRpWm | CbTmRoRpWm | CbTmRoRpWm | CbTmRoRpWm | CbTmRoRpWm | CbTmRoRpWm |
| | limitations | | | | | |
| p | 0 0 0 0 0 | 0 0 0 0 0 | 1 1 1 0 1 | | | |
| d | 0 0 0 0 0 | 1 1 1 0 1 | 2 2 2 1 2 | 1 3 2 2 3 | 2 4 4 3 4 | 2 2 2 2 0 |
| m | 0 0 0 0 0 | 2 0 1 0 0 | 3 1 2 1 0 | 4 2 3 2 1 | 4 3 4 3 2 | |
| n | 0 0 0 0 0 | 2 2 2 1 1 | | | | |
| a | 0 0 0 0 0 | 1 1 1 1 1 | 1 0 1 1 1 | 2 2 2 2 2 | 2 2 2 3 2 | |
| s | 0 0 0 0 0 | 1 1 2 3 1 | 3 3 3 4 3 | 4 4 4 4 4 | 4 4 4 4 4 | |
| t | 0 0 0 0 0 | 1 1 1 0 1 | 2 2 2 1 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 3 4 3 3 2 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 1 | 0 0 0 0 2 | 2 2 2 2 3 | |
| e | 0 0 0 0 0 | 2 2 2 2 2 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 |
| c | 0 0 0 0 0 | 0 0 0 0 0 | 1 0 2 1 2 | | | |

Code for dryland rabi crops :

Cb : cabbage and cauliflower
Tm : tomatoes
Rc : rabi chillies
Rp : rabi pulses, legumes and oilseeds
Wm : watermelon

Table 8A.3 : Relationship between land factor classes and limitations for individual boro crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of boro | | | | | |
| | LbQbSb | LbQbSb | LbQbSb | LbQbSb | LbQbSb | LbQbSb |
| | limitations | | | | | |
| p | 2 2 2 | 1 1 1 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s | 0 0 0 | 1 1 1 | 2 2 2 | 4 4 4 | 4 4 4 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 | 2 4 4 |
| i | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 1 2 | 1 2 3 |
| f | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 2 | 2 2 3 | |
| e | 0 0 0 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 0 0 0 | 0 0 0 | | | |

Code for boro crops :

Lb : local boro varieties
Qb : quick maturing HYV varieties
Sb : slowly maturing HYV varieties

Table 8A.4 : Relationship between land factor classes and limitations for broadcast wetland kharif crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | broadcast wetland kharif crop | | | | | |
| | BuJtBa | BuJtBa | BuJtBa | BuJtBa | BuJtBa | BuJtBa |
| | limitations | | | | | |
| p | 2 2 2 | 0 0 0 | 1 1 0 | | | |
| d | 0 0 0 | 0 0 0 | 1 1 0 | 1 2 1 | 3 4 3 | 1 2 0 |
| m | 0 0 0 | 0 0 0 | 0 1 0 | 2 2 2 | 3 3 3 | |
| n | 0 0 0 | 1 2 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s | 0 0 0 | 1 1 1 | 1 1 1 | 3 3 3 | 4 4 4 | |
| t | 0 0 0 | 1 2 1 | 2 3 2 | 3 3 3 | | |
| w | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 | 4 4 4 |
| i | 0 0 3 | 0 0 2 | 1 1 0 | 2 2 0 | 4 4 2 | 4 4 3 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | 4 3 3 | |
| e | 0 0 0 | 2 2 2 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 1 1 1 | 2 2 2 | | | |

Code for broadcast wetland kharif crops :

Bu : broadcast aus
Jt : jute
Ba : broadcast aman

Table 8A.5 : Relationship between land factor classes and limitations for individual transplanted aus crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of transplanted aus | | | | | |
| | LuIuHu | LuIuHu | LuIuHu | LuIuHu | LuIuHu | LuIuHu |
| | limitations | | | | | |
| p | 2 2 2 | 1 1 1 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | 4 4 4 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 3 3 3 | 2 2 2 | 1 1 1 | 0 0 0 | 0 0 0 | 2 2 2 |
| i | 0 0 0 | 0 0 0 | 0 0 3 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 3 | 3 3 4 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 1 1 1 | 2 2 2 | | | |

Code for transplanted aus crops :

Lu : local variety
Iu : local improved ~~variety~~ variety
Hu : high yielding variety

Table 8A.6 : Relationship between land factor classes and limitations for individual dryland kharif crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of dryland kharif crops KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc |
| | | | limitations | | | |
| p | 0 0 0 0 | 1 1 1 2 | 3 3 3 3 | | | |
| d | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | 3 3 2 3 | 4 4 4 4 | 2 2 2 2 |
| m | 0 0 0 0 | 0 0 0 0 | 0 0 0 1 | 0 1 0 2 | 1 2 1 2 | |
| n | 0 0 0 0 | 1 1 1 1 | | | | |
| a | 0 0 0 0 | 0 1 0 0 | 1 0 1 2 | 2 2 3 3 | 1 2 2 1 | |
| s | 0 0 0 0 | 0 1 1 0 | 1 1 2 1 | 2 2 2 2 | 3 3 3 3 | |
| t | 0 0 0 0 | 1 1 2 1 | 2 2 3 2 | 1 1 1 1 | | |
| w | 0 0 0 0 | 2 2 2 2 | 3 3 3 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 3 3 3 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 2 2 2 2 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| c | 2 2 2 3 | 2 2 2 3 | 1 1 1 2 | | | |
| | KcKiKpKv | KcKiKpKv | KcKiKpKv | KcKiKpKv | KcKiKpKv | KcKiKpKv |
| p | 0 0 0 0 | 1 0 1 1 | 2 2 2 2 | | | |
| d | 0 0 0 0 | 1 1 0 1 | 2 2 1 2 | 2 2 2 2 | 4 4 3 4 | 2 2 2 2 |
| m | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 1 0 0 | 1 2 1 1 | |
| n | 0 0 0 0 | 1 1 1 1 | | | | |
| a | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | 3 3 3 3 | |
| s | 0 0 0 0 | 0 0 1 0 | 1 1 2 1 | 2 2 2 2 | 3 3 3 3 | |
| t | 0 0 0 0 | 1 1 0 1 | 2 2 1 2 | 1 1 1 1 | | |
| w | 0 0 0 0 | 2 2 2 2 | 3 3 3 3 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 3 3 3 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 2 2 2 2 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| c | 2 2 2 2 | 2 2 2 2 | 1 1 1 1 | | | |

Code for dryland kharif crops :

Ks : kharif sorghum
Km : kharif maize
Kg : kharif groundnuts
Kc : kharif cotton
Ko : kharif soybeans
Ki : kharif chillies
Kp : kharif pulses
Kv : kharif vegetables

Table 8A.7 : Relationship between land factor classes and limitations for individual transplanted aman crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of transplanted aman | | | | | |
| | LaIaHa | LaIaHa | LaIaHa | LaIaHa | LaIaHa | LaIaHa |
| | limitations | | | | | |
| p | 2 2 2 | 1 1 1 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | 3 3 3 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 3 3 3 | 2 2 2 | 1 1 1 | 0 0 0 | 0 0 0 | 2 2 2 |
| i | 0 0 0 | 0 0 0 | 0 0 3 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 3 | 3 3 4 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 0 0 1 | 1 1 1 | 2 2 3 | | | |
| (c for U) | 0 0 1 | 1 1 2 | 3 3 4 | | | |

Code for transplanted aman crops :

La : local variety
Ia : local improved variety
Ha : high yielding ~~varie~~ variety

(c for U) = climate rating for transplanted aman in t.aus-t.aman ~~rotation~~ rotation

Table 8A.8 : Relationship between land factor classes and limitations for perennial crops under traditional management without irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of perennial crops | | | | | |
| | S P B F | S P B F | S P B F | S P B F | S P B F | S P B F |
| | limitations | | | | | |
| p | 0 0 0 0 | 0 1 0 1 | 2 2 2 2 | | | |
| d | 0 0 0 0 | 0 0 0 0 | 1 1 1 0 | 3 2 2 3 | 4 3 3 4 | 0 0 0 0 |
| m | 0 0 0 0 | 0 0 1 0 | 1 1 2 0 | 2 2 3 1 | 3 3 4 2 | |
| n | 0 0 0 0 | 2 2 2 1 | | | | |
| a | 0 2 0 0 | 1 3 0 2 | 1 0 1 0 | 2 1 2 1 | 2 3 2 3 | |
| s | 0 0 0 0 | 0 2 2 2 | 2 4 4 4 | 3 4 4 4 | 4 4 4 4 | |
| t | 0 0 0 0 | 0 1 0 0 | 1 2 1 0 | 3 3 3 3 | | |
| w | 0 0 0 0 | 1 2 1 2 | 2 3 2 2 | 3 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 2 4 3 4 | 3 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 0 0 0 1 | 1 1 1 2 | 2 2 2 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 0 1 0 0 | 1 2 1 0 | 2 3 2 1 | 3 4 3 2 | 4 4 4 3 |
| c | 2 1 2 1 | 2 2 2 0 | 2 3 3 1 | | | |
| | T R C | T R C | T R C | T R C | T R C | T R C |
| p | 0 0 0 | 1 0 0 | 2 2 2 | | | |
| d | 0 0 0 | 0 0 0 | 1 0 0 | 3 3 3 | 4 4 4 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 1 0 0 | 2 1 1 | 3 2 2 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 2 1 0 | 3 2 0 | 0 0 1 | 1 1 2 | 4 3 2 | |
| s | 0 0 0 | 2 2 0 | 4 4 0 | 4 4 1 | 4 4 3 | |
| t | 0 0 0 | 0 0 0 | 0 0 0 | 1 3 3 | | |
| w | 0 0 0 | 2 1 0 | 3 2 1 | 4 4 3 | 4 4 4 | 4 4 4 |
| i | 0 0 0 | 4 4 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | 4 4 4 | |
| e | 0 0 0 | 0 0 0 | 0 0 1 | 1 0 2 | 2 2 3 | 3 3 4 |
| c | 1 1 1 | 2 2 2 | 3 3 3 | | | |

Code for perennial crops :

S : sugarcane
P : pineapple
B : bananas
F : fruit trees

T : Tea
R : Rubber
C : coconuts

Table 8B.1 : Relationship between land factor classes and limitations for different land use types under traditional management with irrigation

| land factor | Land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | land use type RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP | RBWAKTP |
| | limitations | | | | | |
| p | 1423031 | 0101111 | 2010202 | | | |
| d | 0000000 | 1000000 | 2010101 | 2010213 | 3131324 | 2010200 |
| m | 0000000 | 0000000 | 1000000 | 2000001 | 3110102 | |
| n | 0000000 | 1111111 | | | | |
| a | 0000000 | 1111111 | 1111110 | 2222222 | 2222222 | |
| s 1/ | 0000000 | 1000001 | 2211114 | 3333333 | 4444334 | |
| t | 0000000 | 1010100 | 2121211 | 1313133 | | |
| w | 0302020 | 0202121 | 0001303 | 0000404 | 3000404 | 4242424 |
| i | 0000000 | 0000404 | 0012424 | 0024444 | 0034444 | 0044444 |
| f | 0000000 | 0000001 | 0011112 | 0122222 | 0333434 | |
| c | 0000000 | 3433333 | 4444444 | 4444444 | 4444444 | 4444444 |
| c | 0111201 | 0000201 | 0000100 | | | |

Code for land use types :

R : dryland rabi crops
B : boro
W : broadcast wetland kharif crops
A : transplanted aus
K : dryland kharif crops
T : transplanted aman
P : perennial crops

1/ If irrigation water is not saline, use 's0' rating.

Table 8B.2 : Relationship between land factor classes and limitations for individual dryland crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | dryland rabi crops | | | | | |
| | WhMiRaRmRc | WhMiRaRmRc | WhMiRaRmRc | WhMiRaRmRc | WhMiRaRmRc | WhMiRaRmRc |
| | limitations | | | | | |
| p | 1 1 1 1 1 | 0 0 0 0 0 | 2 2 2 2 2 | | | |
| d | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 3 3 3 3 3 | 4 4 4 4 4 | 3 3 3 3 3 |
| m | 0 0 0 0 0 | 0 0 0 0 0 | 1 0 1 1 1 | 2 0 2 2 2 | 3 1 3 3 3 | |
| n | 0 0 0 0 0 | 1 1 1 2 2 | | | | |
| a | 0 0 0 0 0 | 0 0 0 1 0 | 1 1 1 0 2 | 2 2 2 2 3 | 1 1 1 2 1 | |
| s 1/ | 0 0 0 0 0 | 1 1 1 2 1 | 1 1 2 3 1 | 3 3 3 4 2 | 4 4 4 4 3 | |
| t | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 0 2 | 0 0 0 0 3 | 0 0 0 0 4 | 3 0 3 3 4 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 1 0 0 0 | 0 2 0 0 0 | 2 3 2 2 2 | |
| e | 0 0 0 0 0 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 |
| c | 0 0 0 0 2 | 0 0 0 0 1 | 0 0 0 0 0 | | | |
| | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb | PoRgSfToSb |
| p | 1 1 1 1 1 | 0 0 0 0 0 | 2 2 2 2 2 | | | |
| d | 0 0 0 0 0 | 1 1 1 1 1 | 2 2 2 2 2 | 2 2 3 2 2 | 3 4 4 3 4 | 0 2 2 2 2 |
| m | 0 0 0 0 0 | 0 0 0 0 0 | 1 0 1 1 0 | 2 1 2 2 1 | 3 2 3 3 2 | |
| n | 0 0 0 0 0 | 1 1 1 1 1 | | | | |
| a | 0 0 0 0 0 | 2 1 1 2 1 | 1 1 1 1 1 | 2 2 2 2 2 | 3 2 2 3 2 | |
| s 1/ | 0 0 0 0 0 | 2 1 0 2 0 | 3 4 2 4 3 | 4 4 4 4 4 | 4 4 4 4 4 | |
| t | 0 0 0 0 0 | 1 2 1 1 1 | 2 3 2 2 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 1 0 | 0 0 0 1 0 | 0 0 0 2 0 | 3 4 4 4 4 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 2 2 2 2 2 | |
| e | 0 0 0 0 0 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 |
| c | 0 0 0 2 0 | 0 0 0 1 0 | 0 0 0 0 0 | | | |

Code for dryland rabi crops :

Wh : wheat and barley
Mi : millet
Rs : rabi sorghum
Rm : rabi maize
Rc : rabi cotton

Po : potatoes
Rg : rabi groundnuts
Sf : sunflower
To : tobacco
Sb : soybeans

1/ If irrigation water is not saline, use 's0' rating.

Table 8B.2 (continued)

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | dryland rabi crops | | | | | |
| | CbTmRcRpWm | CbTmRcRpWm | CbTmRcRpWm | CbTmRcRpWm | CbTmRcRpWm | CbTmRcRpWm |
| | limitations | | | | | |
| p | 1 1 1 1 1 | 0 0 0 0 0 | 2 2 2 2 2 | | | |
| d | 0 0 0 0 0 | 1 1 1 0 1 | 2 2 2 1 2 | 1 3 2 2 3 | 2 4 4 3 4 | 2 2 2 2 0 |
| m | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 1 0 0 | 1 1 2 1 1 | 2 2 3 2 1 | |
| n | 0 0 0 0 0 | 2 2 2 1 1 | | | | |
| a | 0 0 0 0 0 | 1 1 1 1 1 | 1 0 1 1 1 | 2 2 2 2 2 | 2 2 2 3 2 | |
| s 1/ | 0 0 0 0 0 | 1 1 2 3 1 | 3 3 3 4 3 | 4 4 4 4 4 | 4 4 4 4 4 | |
| t | 0 0 0 0 0 | 1 1 1 0 1 | 2 2 2 1 2 | 1 1 1 1 1 | | |
| w | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 3 4 3 3 2 | 4 4 4 4 4 |
| i | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 |
| f | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 1 | 0 0 0 0 2 | 2 2 2 2 3 | |
| e | 0 0 0 0 0 | 3 3 3 3 3 | 4 4 4 4 4 | 4 4 4 4 4 | 4 4 4 4 4 | |
| c | 0 0 0 0 0 | 0 0 0 0 0 | 0 0 0 0 0 | | | |

Code for dryland rabi crops :

Cb : cabbages and cauliflower
Tm : tomatoes
Rc : rabi chillies
Rp : rabi pulses and legumes
Wm : watermelon

1/ If ~~irrigqx~~ irrigation water is not saline, use 's0' rating.

Table 8B.3 : Relationship between land factor classes and limitations for individual boro crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of boro | | | | | |
| | LbQbSb | LbQbSb | LbQbSb | LbQbSb | LbQbSb | LbQbSb |
| | limitations | | | | | |
| p | 4 4 4 | 1 1 2 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | |
| n | 0 0 0 | 0 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s 1/ | 0 0 0 | 1 1 1 | 2 2 2 | 4 4 4 | 4 4 4 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 3 3 3 | 2 2 2 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 |
| i | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 1 2 | 1 2 3 |
| f | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 2 | 2 2 3 | |
| e | 0 0 0 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 0 0 0 | 0 0 0 | | | |

Code for boro crops :

Lb : local boro varieties
Qb : quick maturing HYV varieties
Sb : slowly maturing HYV varieties

1/ If irrigation water is not saline, use 'sO' rating.

Table 8B.4 : Relationship between land factor classes and limitations for broadcast wetland kharif crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | broadcast wetland kharif crops | | | | | |
| | BuJtBa | BuJtBa | BuJtBa | BuJtBa | BuJtBa | BuJtBa |
| | limitations | | | | | |
| p | 2 2 2 | 0 0 0 | 1 1 1 | | | |
| d | 0 0 0 | 0 0 0 | 1 1 0 | 1 2 1 | 3 4 3 | 1 2 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | |
| n | 0 0 0 | 1 2 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s 1/ | 0 0 0 | 1 1 1 | 1 1 1 | 3 3 3 | 4 4 4 | |
| t | 0 0 0 | 1 1 1 | 2 2 2 | 3 3 2 | | |
| w | 0 0 3 | 0 0 3 | 0 0 3 | 0 0 0 | 2 2 2 | 4 4 4 |
| i | 0 0 0 | 0 0 0 | 1 1 0 | 2 2 0 | 4 4 2 | 4 4 3 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | 4 3 3 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 0 0 0 | 0 0 0 | | | |

Code for broadcast wetland kharif crops :

Bu : brcadcast aus
Jt : jute
Ba : broadcast aman

1/ If irrigation water is not saline, use 's0' rating.

Table 8B.5 : Relationship between land factor classes and limitations for individual transplanted aus crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of transplanted aus | | | | | |
| | LuIuHu | LuIuHu | LuIuHu | LuIuHu | LuIuHu | LuIuHu |
| | limitations | | | | | |
| p | 3 3 3 | 1 1 2 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s 1/ | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | 4 4 4 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 3 3 3 | 2 2 2 | 1 1 1 | 0 0 0 | 0 0 0 | 2 2 2 |
| i | 0 0 0 | 0 0 0 | 0 0 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 3 | 3 3 4 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 1 1 1 | 0 0 0 | 0 0 0 | | | |

Code for transplanted aus crops :

Lu : local ~~vare~~ variety
Iu : local improved variety
Hu : high yielding variety

1/ If irrigation water is not saline, use 'sO' rating.

Table 8B.6 : Relationship between land factor classes and limitations for individual dryland kharif crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of dryland kharif crops | | | | | |
| | KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc | KsKmKgKc |
| | limitations | | | | | |
| p | 0 0 0 0 | 1 1 1 2 | 2 2 2 2 | | | |
| d | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | 3 3 2 3 | 4 4 4 4 | 2 2 2 2 |
| m | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | |
| n | 0 0 0 0 | 1 1 1 1 | | | | |
| a | 0 0 0 0 | 0 1 0 0 | 1 0 1 2 | 2 2 3 3 | 1 2 2 1 | |
| s 1/ | 0 0 0 0 | 0 1 1 0 | 1 1 2 1 | 2 2 2 2 | 3 3 3 3 | |
| t | 0 0 0 0 | 1 1 2 1 | 2 2 3 2 | 1 1 1 1 | | |
| w | 0 0 0 0 | 2 2 2 3 | 3 3 3 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 3 3 3 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 3 3 3 3 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| c | 2 2 2 3 | 2 2 2 3 | 1 1 1 2 | | | |
| | KoKiKpKv | KoKiKpKv | KoKiKpKv | KoKiKpKv | KoKiKpKv | KoKiKpKv |
| p | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | | | |
| d | 0 0 0 0 | 1 1 0 1 | 2 2 1 2 | 2 2 2 2 | 4 4 3 4 | 2 2 2 2 |
| m | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | |
| n | 0 0 0 0 | 1 1 1 1 | | | | |
| a | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | 3 3 3 3 | |
| s 1/ | 0 0 0 0 | 1 1 1 1 | 1 1 1 1 | 2 2 2 2 | 3 3 3 3 | |
| t | 0 0 0 0 | 1 1 0 1 | 2 2 1 2 | 1 1 1 1 | | |
| w | 0 0 0 0 | 2 2 2 2 | 3 3 3 3 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 0 0 0 0 | 1 1 1 1 | 3 3 3 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 3 3 3 3 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| c | 2 2 2 2 | 2 2 2 2 | 1 1 1 1 | | | |

Code for dryland kharif crops :

Ks : kharif sorghum
Km : kharif maize
Kg : kharif groundnuts
Kc : kharif cotton
Ko : kharif soybeans
Ki : kharif chillies
Kp : kharif pulses
Kv : kharif vegetables

1/ If irrigation water is not saline, use 's0' rating.

Table 8B.7 : Relationship between land factor classes and limitations for individual transplanted aman crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of transplanted aman | | | | | |
| | LaIaHa | LaIaHa | LaIaHa | LaIaHa | LaIaHa | LaIaHa |
| | limitations | | | | | |
| p | 3 3 3 | 1 1 1 | 0 0 0 | | | |
| d | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 1 1 1 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 0 0 0 | 1 1 1 | 1 1 1 | 2 2 2 | 2 2 2 | |
| s 1/ | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 2 | 3 3 3 | |
| t | 0 0 0 | 0 0 0 | 1 1 1 | 3 3 3 | | |
| w | 2 2 2 | 2 2 2 | 0 0 0 | 0 0 0 | 0 0 0 | 2 2 2 |
| i | 0 0 0 | 0 0 0 | 0 0 3 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 0 0 0 | 1 1 1 | 2 2 3 | 3 3 4 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 0 0 1 | 0 0 0 | 0 0 0 | | | |

Code for transplanted aman crops :

La : local variety
Ia : local improved variety
Ha : high yielding variety

1/ If irrigation water is not saline, use 'sO' rating.

Table 8B.8 : Relationship between land factor classes and limitations for individual perennial crops under traditional management with irrigation

| land factor | land factor classes 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | type of perennial crop | | | | | |
| | S P B F | S P B F | S P B F | S P B F | S P B F | S P B F |
| | limitations | | | | | |
| p | 2 1 1 0 | 1 1 1 1 | 2 2 2 2 | | | |
| d | 0 0 0 0 | 0 0 0 0 | 1 1 1 0 | 3 2 2 3 | 4 3 3 4 | 0 0 0 0 |
| m | 0 0 0 0 | 0 0 0 0 | 0 0 0 0 | 1 0 2 0 | 2 1 3 1 | |
| n | 0 0 0 0 | 2 2 2 1 | | | | |
| a | 0 2 0 0 | 1 3 0 2 | 1 0 1 0 | 2 1 2 1 | 2 3 2 3 | |
| s 1/ | 0 0 0 0 | 0 2 2 2 | 2 4 4 4 | 3 4 4 4 | 4 4 4 4 | |
| t | 0 0 0 0 | 0 1 0 0 | 1 2 1 0 | 3 3 3 3 | | |
| w | 0 0 0 0 | 1 2 1 2 | 3 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| i | 0 0 0 0 | 2 4 3 4 | 3 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| f | 0 0 0 0 | 1 1 1 1 | 2 2 2 2 | 3 3 3 3 | 4 4 4 4 | |
| e | 0 0 0 0 | 3 3 3 3 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 | 4 4 4 4 |
| c | 2 1 2 1 | 1 1 1 0 | 0 0 0 0 | | | |
| | T R C | T R C | T R C | T R C | T R C | T R C |
| p | 0 0 0 | 1 1 1 | 2 2 2 | | | |
| d | 0 0 0 | 0 0 0 | 1 0 0 | 3 3 3 | 4 4 4 | 0 0 0 |
| m | 0 0 0 | 0 0 0 | 0 0 0 | 2 1 1 | 3 2 2 | |
| n | 0 0 0 | 1 1 1 | | | | |
| a | 2 1 0 | 3 2 0 | 0 0 1 | 1 1 2 | 4 3 2 | |
| s 1/ | 0 0 0 | 1 1 0 | 3 3 1 | 4 4 1 | 4 4 3 | |
| t | 0 0 0 | 0 0 0 | 0 0 0 | 1 3 3 | | |
| w | 0 0 0 | 2 1 0 | 3 2 1 | 4 4 3 | 4 4 4 | 4 4 4 |
| i | 0 0 0 | 4 4 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| f | 0 0 0 | 1 1 1 | 2 2 2 | 3 3 3 | 4 4 4 | |
| e | 0 0 0 | 3 3 3 | 4 4 4 | 4 4 4 | 4 4 4 | 4 4 4 |
| c | 0 0 0 | 0 0 0 | 0 0 0 | | | |

Code for perennial crops :

S : sugarcane
P : pineapples
B : bananas
F : fruit trees

T : tea
R : rubber
C : coconuts

1/ If irrigation water is not saline, use 's0' rating.

## REFERENCES

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