Eurasian Journal of Analytical Chemistry
ISSN: 1306-3057 OPEN ACCESS 2018 13 (6): 170-177

# Potential of Critical Land for Sorghum (Sorghum Bicolor) Development in Indrapuri Sub-District, Aceh Besar District, Aceh Province

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Received 14 September 2018 ▪ Revised 23 October 2018 ▪ Accepted 24 November 2018

***Abstract:*** The purpose of this study was to analyze the critical land conditions qualitatively and quantitatively as well as the development potential for sorghum in Indrapuri sub-district, Aceh Besar District. The study used a survey method based on the 2004 Critical Land Spatial Data Preparation Technical Guidelines. The data analysis technique was using overlay method and ground checking directly in the field. The results showed that there were 3 (three) categories of critical land in the cultivation area in Indrapuri Subdistrict, Aceh Besar District, that is uncritical land with a score of 470 covering an area of 5,280 ha, moderately critical land with a score of 290-320 covering 6,562 ha, and critical land with a score of 220 -260 covering an area of 3,135 ha. The land with various levels of criticality generally has a very low to low level of soil fertility with the level of land suitability for sorghum plants ranging from moderately suitable (S2) and marginally suitable (S3).

***Keywords:*** Critical land, Sorghum bicolor, Indrapuri.

## BACKGROUND

Critical land is land that has been damaged physically, chemically and biologically, consequently the land cannot function as a production medium or as a water system. Critical land in Indonesia, including in Aceh, continues to increase every year which results in a reduction in productive land and in turn it can threaten food security and environmental sustainability (Widianto et al., 2003)

Based on the data of The Directorate General of Land Rehabilitation and Social Forestry of Indonesian Ministry of Forestry in 2007 showed that the critical land area in Indonesia reaches 77.8 million ha, which consists of moderately critical 47.6 million ha, critical 23.3 million ha and very critical 6.9 million ha. In Aceh Province, the critical land area reached 860,659.93 ha, with details: very critical 5,777 ha, critical 320,248.13 ha, moderately critical 96,738.29 ha, and potential critical 437,896.51 ha (Ministry of Forestry and Plantation, 2000). In Aceh Besar District, the critical land area reached 31,319 ha consisting of critical land within forest area covering 7,819 ha, moderately critical 1,059 ha and outside the critical land forest area 17,921 ha and moderately critical 4,520 ha (Aceh Besar in Figures 2011).

The efforts to increase land productivity to support regional and national food security, the recovery of critical land to productive land is an important alternative in line with population growth and land use change. The use of critical land can be in the form of efforts to increase the productivity of land that has been abandoned into productive land for cultivation of food crops.

Regarding the above problems, it is important to conduct a study of critical land rehabilitation in Aceh Besar District to obtain an effective technological package direction in the development of sustainable food crops in the area. This critical land rehabilitation study is also expected to be a reference in determining policies in increasing the productivity of critical land for sustainable food crop agricultural production in Aceh Besar District. The targets to be achieved from this study include: as a directive for the government in setting policies in agriculture, making it easier to identify problems and agricultural potential; become a reference in planning the development of agricultural commodities.

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## METHODOLOGY

The study used a survey method that was carried out for two months, starting from May to June 2013 in Indapuri sub-district, Aceh Besar District, Aceh Province. The method for critical land analysis is based on Technical Guidelines for Critical Land Spatial Data Preparation (2004) by the Directorate General of Land Rehabilitation and Social Forestry (RLPS) and Letter of the Director General of RLPS No. S.296 / V-SET / 2004 dated October 5, 2004. Basically, the technique used in this analysis is the overlay method and direct observation in the field.

The spatial data of critical land is obtained from the results of analysis of some spatial data which is a determining parameter of land criticality based on the Decree of the Directorate of General of land reclamation and rehabilitation (RRL) No. 041 / Kpts / V / 1998 include: (a) Conditions of land cover, (b) slope, (c) erosion hazard level, and, (d) management (management) conditions, (e) land productivity, and (f) map of land status. Spatial analysis is carried out by overlaying spatial data on critical land determining parameters to produce a new mapping unit that will be used as an analysis unit. In each unit of analysis, the attribute data is analyzed, which is tabular data with the scoring method. Each critical parameter determines the land given a certain score and then added to the spatial data output analysis unit.

The summation results are then classified to determine the level of criticality of the land in accordance with the criteria set by the Directorate of RKT Director General of RRL No. 041 / Kpts / V / 1998 Ministry of Forestry in 1998 for cultivation areas (Tables 1 and 2).

## RESULT AND DISCUSSION

### Critical Land Area and Area Allocation

Critical land is defined as land whose use is not in accordance with its capabilities so that it experiences physical, chemical and biological damage. This condition endangers the hydrological, agricultural production, settlement and socio-economic conditions. According to the records of Land and agro-climate research center (2003) defines critical land as land that has suffered physical damage to the soil due to reduced vegetation cover and the presence of symptoms of erosion which ultimately endanger the hydrological function and the environment.

Table 1: Criteria for Critical Land for Agricultural areas

| No | Cruteria (% weight) | Class | Description | Score |
|---|---|---|---|---|
| 1 | Productivity*) (30) | 1. Very high<br>2. High<br>3. Medium<br>4. Low<br>5. Very low | >80 %<br>61-80 %<br>41-60 %<br>21-40 %<br>< 20 % | 5<br>4<br>3<br>2<br>1 |
| 2 | Slope (20) | 1. Flat<br>2. Ramps<br>3. Slightly Steep<br>4. Steep<br>5. Very Steep | < 8 %<br>8- 15 %<br>16-25 %<br>25-40 %<br>> 40 % | 5<br>4<br>3<br><br>2<br>1 |
| 3 | Erosion (20) | 1. Light | • Soil is depth: <25% of the topsoil is eroded and or rill erosion at a distance of 20-50 m<br>• Soil is shallow: <25% of topsoil is eroded and or rill erosion at a distance of > 50 m | 5 |
| | | 2. Medium | • Soil is depth: 25-75% of top soil is eroded and or rill erosion at a distance of 20 m<br>• Soil is shallow: 25-50% of top soil is eroded and or rill erosion with a distance of <20-50 m | 4 |
| | | 3. Heavy | • Soil is depth: more than 75% of the topsoil is eroded and or rill erosion at a distance of 20-50 m<br>• Soil is shallow: 25-75% of top soil layers disappear | 3 |
| | | 4. Very heavy | • Soil is depth: topsoil are eroded, > 25% of the subsoil is eroded and or rill erosion at a distance of <20 m<br>• Soil is shallow:> 75% of the topsoil has been lost and partly subsoil is eroded | 2 |
| 4 | Management (30) | 1. Good<br>2. Medium<br>3. Bad | • Application of complete soil conservation technology and in accordance with technical instructions<br>• Not complete and not maintained management<br>• No management applied | 5<br><br>3<br>1 |

(*) Rated based on the ratio of optimal general production to traditional management

The results showed that the total area in Indrapuri District was 19,947 ha. Based on information from the Aceh Besar District Spatial Plan and Area in 2010, in Indrapuri District there were 14,224 ha (71%), protected forest areas 4,971 ha (25%), protected areas outside forest areas 748 ha (4%).

The main characteristics of critical land are unfertile, unproductive, and even rocks on the ground. The topography is generally hilly or steep slope. Low productivity levels are characterized by high levels of soil acidity. Nutrients of N, P, K, C and Mg are low. In addition, the low CEC, base saturation and organic matter content, on the contrary Al and Mn content are high, which can poison plants. The condition of critical land is characterized by dominating reeds with properties including: having a relatively low soil pH of 4.8 to 5.2, experiencing high leaching in soil, finding large amounts of rhizomes which are mechanical barriers in crop cultivation. There is a reaction of allelopathic substances from the roots of reeds which causes disruption of the growth of cultivated plants on the land (Yunita, 2005).

Table 2: Land Critical Levels in Cultivation Areas for Agriculture (Directorate of Rehabilitation and Soil Conservation 1997)

| No | Critical Land Level | Total value |
|---|---|---|
| 1. | Highly critical | 115-200 |
| 2. | Critical | 201-275 |
| 3. | Moderately critical | 276-350 |
| 4. | Potentially critical | 351-425 |
| 5. | No critical | 426-500 |

**Percentage of Land Cover and Slope**

The term land use (land use) is different from the term land cover. Land use usually includes all types of appearance and has been linked to human activities in utilizing land, while land cover covers all types of features on the earth's surface that exist on certain land. Land use is an important aspect because land use reflects the level of human civilization.

Land cover analysis in Indrapuri Sub-district uses Citra Landsat V. The results of the analysis of land cover, after obtaining field verification resulted in the appearance of the percentage of land cover as shown in Table 3.

Table 3: Conditions of Land cover and Slope in Indrapuri sub-district, Aceh Besar district

| Variables | Area (ha) and Percentage of Land Cover/Category/(Score) | | | | | Luas |
|---|---|---|---|---|---|---|
| | >80 | 60-80 | 41-60 | 21-40 | <20 | (ha/%) |
| | SB (5) | B (4) | SD (3) | BR (2) | SR (1) | |
| Land Cover | 3.511 (18%) | 5.657 (18%) | 5.448 (27%) | 2.452 (12%) | 2.879 (14%) | 19.947 (100%) |
| Slope | Areas (ha) | | | | | Luas |
| | 0-8 (D) | 9-15 (L) | 16-30 (AC) | 31-40 (C) | >40 (SC) | (ha/%) |
| | 4.402 (22%) | 972 (5%) | 5.680 (28%) | 2.662 (13%) | 6.231 (31%) | 19.947 (100%) |

SB = Very good, B = Good, SD = Medium, BR = Bad, SR = Very Bad
D = Flat, L = Ramps, AC = Slightly Steep, C = Steep, and SC = Very Stee

Based on Table 3 it is known that land cover in very good condition (covered> 80%) is only 18% of the total area in the region. While the percentage of land cover in the category of bad to very bad reaches 26% of the total area of the sub-district. This is because in the study area there is a pattern of land management in the form of agroforestry which is a mixture of forestry with plantation crops and food crops and livestock. The land management pattern is presumed to be a land cover condition in Indrapuri Subdistrict where around 67% of the area has a very good to moderate land cover. This is in accordance with the results of Bukhari and Febryano (2009) study, namely, there are three forms of agroforestry on critical land in Indrapuri sub-district namely agrosilviculture, silvopastura, and agrosilvopastur. These lands are scattered around the villages of Anuek Gle, Reukih Dayah, and Krueng Lamkareung village.

The results of digitization analysis of Landsat V imagery and the results of a field measurement observation using abney level note that the slope level of the land in Indrapuri sub-district has a very complex physiography, as shown in Table 3. It is known that critical lands that have slopes of more than 31% reaching 8,893 ha (44%), the land generally has a very high risk or limiting factor for seasonal crop development.

**Level of Erosion and Productivity of Land**

Erosion is the transfer of soil material from its original place to another place mainly due to water as a transporting agent. The level of erosion of a land will greatly affect soil fertility for agriculture. The higher or greater the level of soil erosion, the more infertile and unsuitable the soil is for the development of agricultural crops, especially food crops. Erosion measurement is carried out by direct observation in the field, namely observation of soil surface which includes the reduction in thickness of soil solum, crop rooting outcrops, especially on sloping land. Effective soil depth is the depth of soil that can still be penetrated by plant roots. The number of roots, both fine roots and coarse roots, and the depths of the roots can penetrate the soil and if no plant roots are found, the effective depth is determined based on the depth of soil solum (Hardjowigeno, 1995). The depth of soil solum is classified into; very shallow: <20 cm, shallow: 20 - 50 cm, medium: 50 - 75 cm, and depth:> 75 cm.

The results of field observations on the level of soil erosion in Indrapuri Subdistrict, Aceh Besar District showed that the distribution of the area is based on the actual level of erosion at the study site as presented in Table 4.

Table 4: Land Conditions Based on the Level of Erosion and land Productivity in Indrapuri sub-district, Aceh Besar District

| Variables | Areas (ha) | | | | Areas (ha/%) |
|---|---|---|---|---|---|
| | Low | Medium | Heavy | Very Heavy | |
| Erosion Class | 9.443 (47%) | 5.004 (25%) | 4.024 (20%) | 1.476 (7%) | 19.947 (100%) |
| Land Productivity | Areas (ha) | | | | Luas (ha/%) |
| | High | Medium | Low | Very Low | |
| | 7.735 (39%) | 9.203 (46) | 3.010 (15%) | 0 (0%) | 19.947 (100%) |

Based on Table 4. it is known that the percentage of land area with erosion status is very heavy in Inderapuri Subdistrict, covered 7% of the total district area. It is understandable that in agroforestry systems there is a state of land cover or vegetation above the surface of the land to be one element that can reduce the energy of rainwater to damage the soil structure and the presence of organic matter on lands that are covered by plant canopy throughout the year. This condition is predicted as one of the factors that reduce the rate of erosion on critical land in Indrapuri sub-district. The basic concept of agroforestry in the practice of critical land rehabilitation, including the silvopastoral system can increase farmers' income in a sustainable manner and land use that can prevent flooding and soil erosion (Matatula, 2009).

Land productivity is the ability of the land to produce a product from a management system in a certain area and period. The distribution of area and percentage of area based on the level of land productivity at the study site can be seen in Table 4. Table 4 shows that the level of land productivity in Indrapuri sub-district is known to be 7,735 ha (39%) of the total area of this sub-district has a relatively high land productivity status, and 3,010 ha (15%) belong to categories with low to very low productivity levels.

**Land Management**

Agricultural land management is the action or treatment given to a land to maintain and enhance the productivity of the land by considering its sustainability. The level of land productivity is strongly influenced by soil fertility, rainfall, temperature, humidity, land management systems, and landcover selection (Djaenuddin, 2006). Land management is one of the criteria used to assess land criticality. The results of observations and analysis of the conditions of land management at the study sites have been described as shown in Table 5.

Table 5: Land distribution Areas based on the applied level of Land Management in Indrapuri sub-district, Aceh Besar District

| Sub-district | Description and Land Management Class | | | Areas (ha/%) |
|---|---|---|---|---|
| | Complete*) (Good) | Not Complete (Medium) | None (Bad) | |
| Indrapuri | 5.279 (26%) | 2.297 (12%) | 12.371 (62%) | 19.947 (100%) |

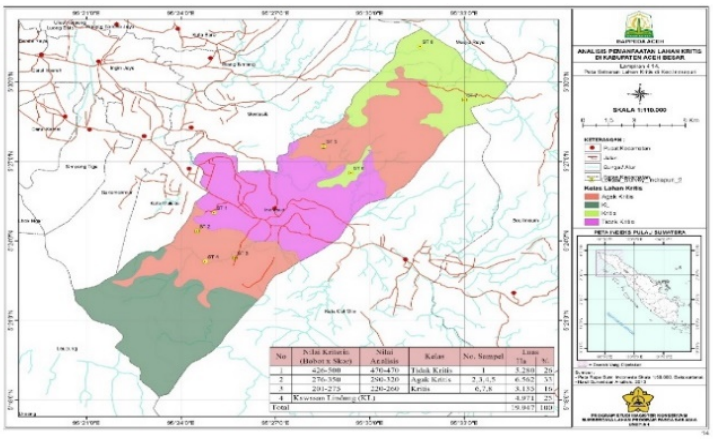
(*) Regional boundary arrangements exist, safeguards and supervision exist, counseling is carried out

**Critical Land Levels and Descriptions**

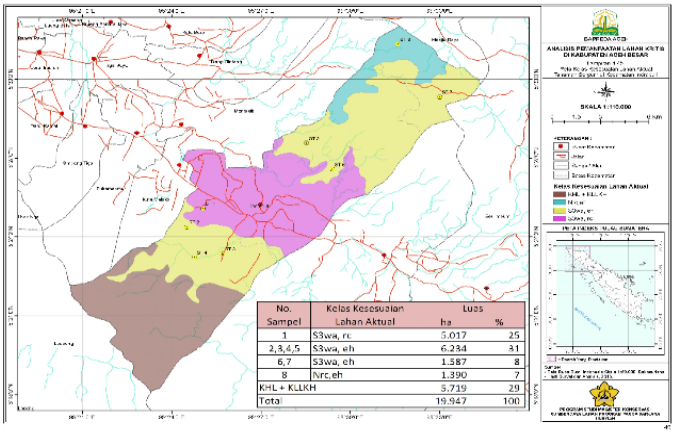
The results of the assessment of the level of criticality and the distribution of land area in Indrapuri sub-district are presented in Figure 1a and Table 6. It is shown that there are 3 (three) categories of critical land in the cultivation area for agricultural land in Indrapuri sub-district namely uncritical, moderately critical, and critical land. In addition, it is also known that land with critical potential and highly critical categories has not been detected in cultivation areas for agriculture in Indrapuri sub-district, Aceh Besar district. Based on the results of field observations and results of laboratory analysis, each level of criticality of land in the observed sub-districts has different characteristics. The characteristics of each land criticality class are described according to the sampling points in the field, as shown in Table 7.

Table 6: Critical Land Distribution in Cultivation Areas for Agriculture in Indrapuri sub-district, Aceh Besar district

| No | Criteria | Analysis Score (weight x score) | Class | No. Sample | Areas | |
|---|---|---|---|---|---|---|
| | | | | | ha | % |
| 1 | 426-500 | 470-470 | No Critical | 1 | 5.280 | 26 |
| 2 | 351-425 | - | Potentially Critical | - | - | - |
| 3 | 276-350 | 290-320 | Moderately Critical | 2,3,4,5 | 6.562 | 33 |
| 4 | 201-275 | 220-260 | Critical | 6,7,8 | 3.135 | 16 |
| 5 | 115-200 | - | Very Critical | - | - | - |
| | Protected Areas | | | | 4.971 | 25 |
| Total | | | | | 19.947 | 100 |



(a)



(b)

Fig 1: Distribution of critical land (a) and Actual land suitability class for sorghum (b) in Indrapuri sub-district, Aceh Besar district, Aceh Province

Table 7: The description of each critical land classes in Indrapuri sub-district, Aceh Besar District

| No | Class | Description | No. Sample | Areas | |
|---|---|---|---|---|---|
| | | | | ha | % |
| 1 | No Critical | Land with a high productivity level, developing on flat slopes with a slope level of <8%, this land experiences low erosion, with the implementation of management at a good level. Sandy loam texture, shallow solum (25-50 cm), CEC ≤ 16 me, Base Saturation ≤ 50%, pH neutral, organic C,> 0.4%, and surface rock <5%. | 1 | 5.017 | 25 |
| 2 | Moderately Critical | Low productivity, developing on gentle slopes with a slope of 8-15%, this land experiences severe erosion, and with moderate management. Clay texture to silty clay, shallow to moderate solum (50-75 cm), CEC ≥ 16 me, Base saturation (BS) ≤ 50%, pH neutral, organic C,> 0.4%, and surface rocks <5% . | 2,3,4 | 2.860 | 14 |
| | | Land with moderate productivity, developing on sloping slopes with a slope of 8-15%, this land experiences severe erosion, and with poor management. Clay texture, moderate solum (50-75 cm), soil CEC ≥ 16 me, BS ≤ 50%, pH neutral, low C-organic (0.14%), and surface rocks <5%. | 5 | 3.374 | 17 |
| 3 | Critical | Land with moderate productivity, developing on sloping slopes with a slope of 8-15%, this land experiences severe erosion, and with poor management. Clay texture, moderate solum (50-75 cm), CEC ≥ 16 me, BS ≤ 50%, pH neutral, low C-organic (0.14%), and surface rocks <5%. | 6,7 | 1.587 | 8 |
| | | Medium productivity, developing in slightly steep slopes with a slope of 16-25%, this land experiences very heavy erosion, and with poor management. Clay texture to sandy clay, very shallow solum (<25 cm), soil CEC ≥ 16 me, BS ≤ 50%, pH slightly acidic, low C-organic (1.57%), and surface rocks 15-40 %. | 8 | 1.390 | 7 |
| 5 | - | KHL + KLLKH | - | 5.719 | 29 |
| Total | | | | 19.947 | 100 |

KHL = Protection Forest Areas; KLLKH = protected areas outside forest areas

**Sorghum Land Suitability (Sorghum bicolor)**

The results of the analysis of land suitability classification for cultivating sorghum on critical land in Indrapuri Subdistrict produce 2 (two) grade levels of actual land suitability, namely marginal suitable (S3) and not suitable (N) (Figure 1b). The results of the actual land suitability evaluation at each critical level of land for sorghum in Indrapuri along with the distribution of the land can be seen in Table 8.

Table 8: Actual Land Suitability Class for Sorghum (Shorgum bicolor) in Indrapuri sub-district, Aceh Besar district

| Critical Level | No Sample | Land Suitability Level | | Limiting Factor | Areas | |
|---|---|---|---|---|---|---|
| | | Class | Sub Class | | ha | % |
| Not Critical | 1 | S3 | S3wa, rc | Water availability in the form of annual average rainfall> 1200 mm, rooting media in the form of shallow soil depth (20-50 cm) | 5.017 | 25 |
| Moderately Critical | 2,3,4,5 | S3 | S3wa, eh, | Water availability in the form of annual average rainfall> 1200 mm, erosion hazard which is classified as heavy | 6.234 | 31 |
| Critical | 6,7 | S3 | S3wa, eh | Water availability in the form of annual average rainfall> 1200 mm, erosion hazard in the form of slopes 16-30% | 1.587 | 8 |
| | 8 | N | Nrc,eh, | Soil depth is very shallow (<25 cm) and erosion hazard is very heavy | 1.390 | 7 |
| - | - | - | - | KHL + KLLKH | 5.719 | 29 |
| Total | | | | | 19.947 | 100 |

Ket: KHL = Protection Forest Areas; KLLKH = protected areas outside forest areas

The land suitability class for sorghum cultivation on critical land in Indrapuri Subdistrict consists of two classes: marginally suitable (S3) and not suitable (N). These lands are found in parts of land with uncritical, moderately critical, and critical levels. Marginal suitable (S3) consists of two sub-classes, and the land does not match only one sub-class. Marginal land suitability sub-class (S3) and not suitable (N) for sorghum cultivation are as follows: (a) S3wa sub class, rc, is found at the areas with the level of not critical land with the limiting factor the availability of water (annual average rainfall> 1200 mm), rooting media shallow soil depth (20-50 cm) with an areas of 5,017 ha (25%), (b) S3wa sub class, with sample point 2 s / d 7 with moderately critical and critical land status. The limiting factor of land use for the development of sorghum on this classes of land is the availability of water with dry months more than 4 months, erosion hazards that are classified as heavy, and slopes of 16-30%. This sub class land area reaches 7,821 ha (39%).

Land with class N category (not suitable) for sorghum in Indrapuri Sub-district is found on the part of land with a "critical" critical level. This land class consists of sub classes namely NRC, uh, includes sample points 8 with the main limiting is very shallow soil depths (<25 cm) and erosion hazards classified as very heavy with an area of 1,390 ha (7%). The limiting factors that can be corrected include the availability of water by construction of small reservoir, and irrigation, providing organic and inorganic fertilizers. The type and level of improvement input provided can improve the class status of land suitability for sorghum. The wide distribution of each class of land classified as potential for sorghum development on critical land in Indrapuri Sub-district is presented in Table 9. After critical lands have been made improvements to reduce the limiting factors, the class status of land suitability for sorghum on critical land change into three suitability classes, namely class S2 (moderately suitable), S3 (marginally suitable), and class N (not suitable). Potentially the S2 class (moderately suitable) for sorghum on critical land in Indrapuri Sub-district is 7,821 ha (39%), marginally potential suitable (S3) covering 5,017 ha (25%), and land that is not suitable (N) in This sub-district was found on very critical land with an area of 1,390 ha (7%).

Table 9: Potential Land Suitability Classes for Sorghum (Sorghum bicolor) in Indrapuri sub-district, Aceh Besar District

| Critical Level | No. Sample | Land Suitability | | Input Management Level | Areas | |
|---|---|---|---|---|---|---|
| | | Actual | Potential | | ha | % |
| Not Critical | 1 | S3 | S3 | Making ponds, embankments, adding organic and inorganic fertilizers, setting the cropping pattern, applying the intercropping system with high to very high inputs | 5.017 | 25 |
| Moderately Critical | 2,3,4 | S3 | S2 | Making ponds, embankments, setting the cropping pattern, intercropping, adding organic and inorganic fertilizers, with medium to high input levels | 2.860 | 14 |
| | 5 | S3 | S2 | Setting cropping patterns, alley cultivation system, intercropping (agroforestry), organic and inorganic fertilization with high to very high input | 3.374 | 17 |
| Critical | 6,7 | S3 | S2 | Setting cropping patterns, alley cultivation system, intercropping (agroforestry), organic and inorganic fertilization with high to very high input | 1.587 | 8 |
| | 8 | N | N | The limiting factor is relatively permanent, the input is very high | 1.390 | 7 |
| - | - | - | - | KHL + KLLKH | 5.719 | 29 |
| Total | | | | | 19.947 | 100 |

KHL = Protection Forest Areas; KLLKH = protected areas outside forest areas

## CONCLUSION

In the area of agricultural cultivation in Indrapuri sub-district there are 3 (three) categories of critical land namely: not critical land with a score of 470 covering an area of 5,280 ha, moderately critical land with a score of 290-320 covering areas of 6,562 ha, and critical land with a score of 220-260 covering areas of 3,135 ha .

Lands with various levels of criticality generally have low to very low soil fertility. Potentially critical land in Indrapuri Subdistrict belongs to moderately suitable (S2) for sorghum, covering areas of 7,821 ha (39%), marginal suitable (S3) covering 5,017 ha (25%), and not suitable (N) covering 1,390 ha (7%). The main limiting factor for sorghum development in Indrapuri sub-district is annual average rainfall> 1,200 mm, shallow soil depth (20-50 cm), and heavy erosion hazard (16-30% slope).

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