Adapting water resources potency for sustainable rice crop systems in Kerinci

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Abstract. Water accessibility and its optimal usage is important for rice land management and climate change resilience. Optimal and adequate water conditions will support utmost rice growth and development. The research aimed to identify water resources accessibility for developing sustainable rice catchment area in Kerinci region. Research was done in 2016 mostly through field surveys. Secondary and primary data were used for supporting further analysis. Each potential water resources such as river, swamps, pump, deep/shallow water in soil surface and others were evaluated. Water buildings facility were also being used as complementary supporting these agricultural service areas. The result showed that water services can be carried out optimally for rice area about 14,375 ha. Strategically, rice production centers specially are located in Danau Kerinci, Keliling Danau and East Air Hangat Sub-district. This research recommendation is useful for policy making and expansion of rice areas in particular. Rice existing land area can still be increased up to 52% based on area coverage.

1. Introduction

Water is a source of life, so in the land and agricultural crops management it is very dependent on water availability [1]. Water accessibility and its optimal usage is important for land management and climate change resilience. Optimal and adequate water conditions will support utmost plant growth and development [2]. Water resources sustainability and its availability will increase productivity of Indonesian strategic agricultural commodities especially rice [3].

On the same hand, adapting land management to climate change is very essential in developing agricultural systems [4]. Increased land use change and climate variation have a direct impact on reducing the level of water availability that will affect the sustainability of its agricultural commodities [5]. Therefore, the efficiency of water utilization and distribution is very important factor in the management of water resources.

Kerinci is one of the main agricultural crop production centres in Jambi. Food crops and horticulture are the leading commodities in this region. Currently, the degradation and land use conversion causes a decrease in the amount of productive land for agricultural crops. One of the main factors in developing agricultural areas, especially food, is the availability of water sources [6]. There are several water sources available in the agricultural area, Kerinci region, but it takes effort to make it available and adaptive for rice cultivation [7].

In this regard, this paper aims to identify water resources for the development of water resources potency for sustainable strategic crop as well as identification of catchment area in which likewise target area/coverage areas that potential to be rice areas in Kerinci district, Jambi.
2. Materials and methods

The scope of activities was done through: preparation of implemented research instructions; coordination, advocacy and monitoring with stakeholders. The implementation procedure uses a quick survey method over and done by a small team (3 persons), field verification of the location for acquiring alternate prospective water resources development and determining the best type for the development [5].

Research activity was mostly carried out through field survey. Others accomplishments were completed by collecting primary and secondary data attained from various relevant sources. The fields activities were accompanied by local agricultural officials, public works administrators, village supervisors and local leaders [8]. The survey was conducted in 2016 and 2017 at Kerinci district, Jambi Province.

The total target area has been determined in general by the Ministry of Agriculture [5], hence, location survey (Ground validating) must be done for the next segment. Some identified information includes: (a) location identity, (b) existing condition, and (c) further recommendations. The data was compiled and prepared for future water resource development plans.

3. Results and discussion

Kerinci District is located in the Western part of the Jambi Province, between: 01°41'S to 02°26'S and 101°08'E to 101°50'E. The topography is hilly land and mountainous with altitude between 500 to 3,805 m above sea level. The areas have high rainfall and prone to erosion. The tropical areas with an average temperature range from 18°C to 26°C. Kerinci District covers an area of 380,850 ha consisting of the Kerinci Seblat National Park Area covering 50.4% or 191,822.3 ha, and cultivation land of 49.6% or 189,027.7 ha. Kerinci District consists of 16 sub-districts.

In general, the Kerinci District can be grouped into several morphological land use areas, namely flat, undulating, rolling to hilly, and mountainous. The orientation to the north it is originated a higher morphology, namely hills and the mountains, while to the south the areas have a lower morphology of lowlands and relatively analogous rocks zones. This condition will certainly affect the distribution of natural resources and be a consideration in determining future space agricultural development allocations.

Most of the Kerinci Regency area (78%) is located at an altitude more than 1,000 m above sea level covering 329,422 ha. Meanwhile, the area between 500 to 1,000 m above sea level is covers 82,422 ha (20%). Whereas, the area less than 500 m above sea level is only 8,136 ha (2%), distributed in 4 sub-districts, namely Gunung Raya, Kumun Debai, Keliling Danau, and Batang Merangin. In sequence, of the 4 sub-districts, Batang Merangin has the largest area with an altitude of 100 to 500 m above sea level. This altitude based area classification will improve water availability within the areas [9].

Water resources identification and characterization based on determining the type of water harvesting infrastructure criteria (table 1). Using its criteria, planning the development for water harvested infrastructure and renovation of water infrastructures have been carried out in Kerinci district. It showed that from the survey area, cultivated land for crop covered 14,375 ha (table 2). Subsequently, result and discussion of both water resources survey on identification and inventory in several districts in Jambi Province, presented bellowed:
Table 1. Criteria for determining the type of water harvesting infrastructure [5, 10].

| No. | Parameters (type of water resources) | Condition | Infrastructure type |
|-----|-------------------------------------|-----------|---------------------|
| 1.  | River Flow                          | Water minimum debit >50 L s⁻¹, river width <18 m, river depth <1.5 m, elevation differences between source of water and cultivation areas <2 m, distance from river to cultivation areas <2 m | Trench Dam |
| 2.  | River flow, Irrigation system, Lake | Water minimum debit >25 L s⁻¹, river width >18 m, river depth >1.5 m, elevation differences between source of water and cultivation areas >2 m, distance from river to cultivation areas <100 m | Water consumptions from river (water pump application) |
| 3.  | Rain water, drainage tunnel, intermittent river | Topography around rough hilly land which is a catchment area (DTA), close to intermittent drainage channels or rivers | Trench Dam |
| 4.  | Rain water, drainage tunnel, intermittent river, tideless river up and down stream | The topography is flat, close to drainage channels, intermittent rivers, or river tides | Long Storage |
| 5.  | Ground water | Deepness of soil water surface <20 m | Shallow well |

Based on determining of water harvesting infrastructure identifications and field survey in several sub-districts, some irrigation networking needs to be repaired and renovated due to damage [11]. In general, irrigation conditions, especially secondary and tertiary channels, are not functioning properly and at some points there are waterways that still need repair [12,13].

Based on the survey results, there are several water resources infrastructure model units in Kerinci, including shallow wells, trench dams and long storage in which each unit has different land cover areas. The largest propose rice area enlargement is by the trench dam unit, which reached 164 detachments or a coverage area of 12,185 ha (table 2). Danau Kerinci sub-district needs improvements of some trench dams with the most widespread service coverage areas reaching 2,149 ha, then followed by Keliling Danau sub-districts (1,828 ha) and Air Hangat Timur (1,778 ha). Other water infrastructures such as long storage are necessary to improve in Depati Tujuh and Siulak Districts, whereas, shallow wells are essentially applied for Gunung Kerinci District (figure 1). A photo and optical picture of existing area conditions related to water resource development needs, can be seen in Figure 2.

Table 2. Identification for water resources infrastructure types in Kerinci regency.

| No. | Water resources infrastructure type | Number of units | Total Coverages area (ha) |
|-----|-----------------------------------|-----------------|--------------------------|
| 1.  | Shallow well                       | 2               | 103.69                   |
| 2.  | Trench Dam                         | 164             | 12,185.11                |
| 3.  | Long Storage                       | 29              | 2,086                    |
| 4.  | Water Pump                         | 0               | 0                        |
| Total|                                   | 195             | 14,375                   |
The results of the water resources survey, for making more precise analyses, it must also be associated with the current existing conditions and the location-specific agricultural development policies in Kerinci. Presently, the main agricultural development based on local strategic commodities in Kerinci is shown in Table 3. The number one food crops commodity in this area is rice. Other commodities such as sweet potato, corn and cassava are also local specific important crop commodities. Taking into account, it is very important to identify the availability of water resources infrastructure for sustainable rice cultivation such as trench dam and long storage. Briefly, based on the acreage and harvested area (Table 4), East Air Hangat sub-district has the largest rice production area (4,298 ha) and Danau Kerinci has the largest harvest area (4,224 ha) [14]. Related and synchronized with the survey data analyzed, both rice existing area can still be increased up to 43% (1,828 ha) and 52% (2,148 ha), with the assumption of no constraint for rice production systems like extraordinary climate conditions (El Niño or La Niña occurrence), adaptive rice seed availability and pest/disease outbreak.
### Table 3. Major agriculture commodities classification in Kerinci district [14].

| No. | Sub-Sector Agriculture | I Superior Rank | II Superior Rank | III Superior Rank | IV Superior Rank | V Superior Rank |
|-----|------------------------|----------------|----------------|----------------|----------------|----------------|
| 1.  | Cereal Crops           | Rice           | Sweet Potato   | Corn           | Cassava        | Peanut and Soybean |
| 2.  | Horticulture Crops     | Potato         | Cabbage        | Chili and Fruits | Tomato        | Radish         |

### Table 4. Rice areas in several sub-districts of Kerinci [14].

| No | Sub-districts | Rice cultivated areas (ha) | Rice harvested areas (ha) |
|----|---------------|----------------------------|---------------------------|
| 1  | Siulak        | 3,101                      | 3,269                     |
| 2  | Gunung Kerinci | 2,485                      | 2,723                     |
| 3  | West Kayu Aro | 195                        | 147                       |
| 4  | Bukit Kerman  | 2,110                      | 2,123                     |
| 5  | Bt. Merangin  | 2,352                      | 1,912                     |
| 6  | Danau Kerinci | 4,166                      | 4,224                     |
| 7  | East Air Hangat | 4,298                     | 3,767                     |
| 8  | Keliling Danau | 3,439                      | 3,530                     |
| 9  | Kayu Aro      | 1,949                      | 1,949                     |
| 10 | Gunung Tujuh  | 1,227                      | 1,227                     |
| 11 | Siulak Mukai  | 2,272                      | 2,331                     |
| 12 | Air Hangat    | 3,144                      | 3,349                     |
| 13 | Sitinjau Laut | 1,506                      | 1,953                     |
| 14 | Depati VII    | 3,301                      | 2,883                     |
| 15 | Gunung Raya   | 1,606                      | 1,423                     |
| 16 | West Air Hangat | 2,118                    | 2,250                     |
|    | Total         | 39,368                     | 39,064                    |

In term of available rice innovation technologies, in some rice production areas located around the survey location has productivity around 5 to 6 t ha⁻¹ [15]. Famous new rice varieties have always been planted in these rice production areas as Inpari 28 Kerinci, and other Inpari rice varieties [16]. Whereas, by sufficiency of water availability, rice cropping index (IP) still can be proposed up to 300 [17]. Applying Jarwo super technologies collaborate with controlling in pest and disease prevalence [18-20], through increasing the use of modern mechanization tools for farmers is also required to enhance rice productivity [21].

### 4. Conclusions

Some areas in Kerinci Regency, have good potential for the development of agricultural areas especially rice cultivation for more than 14,375 ha. In addition, there are also areas that can be increased to twice planting time which was previously planted once with the improvement of water resource facilities. The results of water resources identification and water construction recommendation can be followed up by the relevant agencies in terms of improving facilities, procurement of goods and making facilities to achieve the service area and increasing the productivity of crop commodities, especially rice commodity’. East Air Hangat sub-district has the largest rice production area (4,298 ha) and Danau Kerinci has the largest harvest area (4,224 ha). Related and synchronized with survey results on water resource needs, both rice existing land areas can still be increased up to 43% and 52% respectively.
References

[1] Estiningtyas W, Boer R, Las I and Buono A 2012 Identifikasi deliniasi wilayah endemik kekeringan untuk pengelolaan resiko iklim di Kabupaten Indramayu (in Bahasa) J. Meteo. And geo. 13(1) 9-12
[2] Berrang-Ford L, Biesbroek R and Ford J D 2019 Tracking global climate change adaptation among governments Nat. Clim. Chang. 9 440–449
[3] Haryono and Las I 2011 Strategi Mitigasi dan Adaptasi Pertanian Terhadap Dampak Perubahan Iklim Global (in Bahasa) (Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian Jakarta) p 67
[4] Pratiwi N, Karuniasa Mahawan and Suroso D 2018 Self-organization and crop insurance to enhance livelihood resilience: A case of rice farmers in Cirebon Regency, Indonesia.ASEAN J. Com. Eng. 2 11 1-14
[5] Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian 2018 Petunjuk Pelaksana Kegiatan: Penerapan Inovasi Teknologi untuk Peningkatan Indeks Pertanaman (in Bahasa) Balitbangtan p 28
[6] Hendrayana H 2002 Sistem Pengelolaan Sumber Daya Air Bawah Tanah yang Berkelanjutan dalam Pengelolaan dan Tantangan Pengelolaan Sumber Daya Air di Indonesia S Adi and B Setiadi Eds.) (in Bahasa) Printed ILP3-TPSLKBPP and HSF Jakarta
[7] Wahyunto and F Widiastuti 2014 Lahan sawah sebagai pendukung ketahanan pangan serta strategi pencapaian kemandirian pangan (in Bahasa) J. Sumber Daya Lahan Sp. Ed. 7–30. https://doi.org/10.2018/jsdl.v8i3.6479
[8] Kementerian Pertanian 2015 Pedoman Pedoman Pengawalan dan Pendampingan Terpadu Penyuluhan, Mahasiswa, dan Bintara Pembina Desa dalam Rangka Upaya Khusus Peningkatan Produksi Padi, Jagung dan Kedelai (in Bahasa) Peraturan Menteri Pertanian Jakarta p 34
[9] Subagyo W, Haryati U and Talaohu S H 2004 Teknologi konservasi air pada pertanian lahan kering in konservsai tanah pada lahan kering berlereng (in Bahasa) (Pusat Penelitian dan Pengembangan Tanah dan Agroklimat, Badan Litbang Pertanian. ) pp151-88
[10] Ditjen PSP 2017 Pedoman Teknis Pengembangan Embung Pertanian (in Bahasa) Direktorat Jenderal Prasarana dan Sarana Pertanian Kementerian Pertanian Jakarta p 47
[11] Pusposutardjo S 2001 Pengembangan Iriqasi, Usaha Tani Berkelanjutan dan Gerakan Hemat Air (in Bahasa) (Direktorat Jenderal Pendidikan Tinggi, Departemen Pendidikan Nasional Jakarta) p 195
[12] Saputro S F, Waspodo R and Setiawan B 2016 Perhitungan potensi air tanah di Kecamatan Gabus Wetan (in Bahasa) J. Tek Sipil and Ling. 13 147-58
[13] Supriadi, Herman and Rivai R S 2018 Pengembangan investasi irigasi kecil untuk peningkatan produksi padi mendukung swasembada beras (in Bahasa) An. Jak. Pertanian 16 1 43–57.
[14] Kerinci Regional Statistical Bureau 2019 Kerinci dalam Angka (in Bahasa) Biro Pusat Statistik Kabupaten Kerinci p 323
[15] Hendri J, Adi and Izhar L 2019 Laporan tahunan kegiatan sekolah lapang dan mendiri benih di Kerinci (in Bahasa) BPIT Balitbangtan Jambi BBP2TP Badan Penelitian dan Pengembangan Pertanian p 50
[16] Pusat Penelitian Pengembangan Tanaman 2007 Deskripsi Varietas Unggul Tanaman Pangan 2010-2016 (in Bahasa). Pusat Penelitian dan Pengembangan Tanaman Pangan. Badan Litbang Pertanian. Bogor p 152.
[17] Erythrina 2010 Peluang pengembangan IP padi 400 di lahan sawah irigasi (in Bahasa) Iptek Tan. Pangan 5(1) 1–14.
[18] Koesrini, Saleh M and Nursyamis D 2013 Keragaman varietas inpara di lahan rawa pasang surut (in Bahasa) Pangan 22(3) 221–28.
[19] Pujiharti Y 2017 Peluang peningkatan produksi padi di lahan rawa lebak Lampung (in Bahasa) J. Litbang Pert. 36(1) 13-20 https://doi.org/10.21082/jp3.v36n1.2017.
[20] Tresliyana, Anggita and Erythrina 2012 Prospek peningkatan indeks pertanaman padi 400 di provinsi Sumatra Barat (in Bahasa) Widyariset 15(2) 285–92

[21] Umar, Sudirman, Hidayat A R and S Pangaribuan 2017 Pengujian mesin tanam padi sistem Jajar Legowo (Jarwo Transplanter) di lahan rawa pasang surut (in Bahasa) J. Tek. Pert. Lampung 6(1) 63–72 https://doi.org/10.1159/000286037.