International Journal of Agricultural Technology 2022Vol. 18(6):2559-2572
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Land suitability evaluation of shallot (*Allium ascalonicum* L.) at irrigated marginal lowland in Bengkulu, Indonesia

Rahman, N.[1], Hermawan, B.[2], Reflis[3], Sulistyo, B.[2], Marlin[4] and Barchia, M. F.[2*]

[1]Agricultural Sciences, Faculty of Agriculture, University of Bengkulu, Indonesia; [2]Department of Soil Science, Faculty of Agriculture, University of Bengkulu, Indonesia; [3]Department of Socio-Economics, Faculty of Agriculture, University of Bengkulu, Indonesia; [4]Department of Crop Sciences, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia.

Rahman, N., Hermawan, B., Reflis, Sulistyo, B., Marlin and Barchia, M. F. (2022). Land suitability evaluation of shallot (*Allium ascalonicum* L.) at irrigated marginal lowland in Bengkulu, Indonesia. International Journal of Agricultural Technology 18(6):2559-2572.

Abstract Shallot (*Allium ascalonicum* L.) is one of the strategic vegetable commodities that farmers have been intensively cultivating in almost fertile highlands of Indonesia because of its high economic value and attractive market prospects. The result showed the actual suitability classes for shallot cultivation in the Cawang Kidau irrigation area covered 1,131.73 ha classified in marginal suitable (S3) with the heaviest limiting factors are erosion hazard, nutrients retention and nutrient availability and the rest areas, 193.48 ha classified as unsuitable classes for the shallot cultivation. Efforts to overcome the constrains and to improve from the marginally suitable classes to moderately suitable classes for the shallot cultivation are implementing terrace constructions, amelioration with lime, and optimum fertilizers applied.

Keywords: Inherit soil properties, Land evaluation, Marginal dry lowland, Shallot cultivation

Introduction

Shallot is an economically important nutritive bulb vegetable and medicinal plant from Alliaceae family (Khorasgani and Pessarakli, 2019). In Indonesia, shallot is an important vegetable commodity having strategic value because it is used as spice in dishes and raw material for food industry such as fried shallot (Sulistyaningsih *et al*., 2020). Many Indonesian islands become the centre of the production of shallots, and scattered in almost all the large islands in Indonesia (Prakoso, 2021) with various environmental and agroclimatic conditions therefore the shallot productivity in general only reach about 9.93 tons ha^{-1} (BPS Statistics Indonesia, 2021) which is lower as compared to the world average of 18.8 tons ha^{-1} (Tsagaye *et al*., 2021).

[*] **Corresponding Author:** Barchia, M. F.; **Email**: faizbarchia@unib.ac.id

In 2020, shallot production in Indonesia reached 1,815,445 tons, and the shallot production tend to increase in the last decade however the high shallot production has not enough to cover population demand (Al Rosyid *et al*., 2021). Another problem of shallot supply was the shallot production depending on planting seasons therefore out of these seasons the shallot demands fulfilled through import supplies (Putri *et al*., 2021). In the last two years, Indonesian government had imported an average shallot bulb of 211 tons year^{-1} (Indonesian Ministry of Agriculture, 2020). Along with the increasing population in Indonesia, the need for shallot increases also. To increase the production of shallots can be pursued by the addition of land production and land management that already exist with as much as possible, through land improvement efforts so that the productivity of land will increase. Furthermore (Rahayu *et al*., 2018), Indonesia will develop shallot production and become a self-sufficient state of shallot as well as the leading exporting country of shallots in ASEAN by 2045 with the export targets 40.000 tons year^{-1}. Therefore, to fulfil these targets the addition of shallot production land area would require of 34.307 ha or 1.183 ha year^{-1}.

The high areas of the shallot productions in Indonesia actually were provided in Java which contributed about 78,1 % while others only supplied about 21,9 % (Hasri *et al*., 2020). However, in the last few years, the high productive areas in Java faced with available nutrients degradation especially in the intensive shallot cultivation areas (Purbiati, 2012), therefore to maintain the increasing shallot demands in the future, the shallot cultivation areas should be extended other potential islands in Indonesia (Novita *et al.*, 2019). Also, the expansions of the shallot production areas outside of Java hopefully could provide shallot demands closed to local societies especially in the seasons when the shallot production and supplies decrease (Kiloes *et al*., 2018).

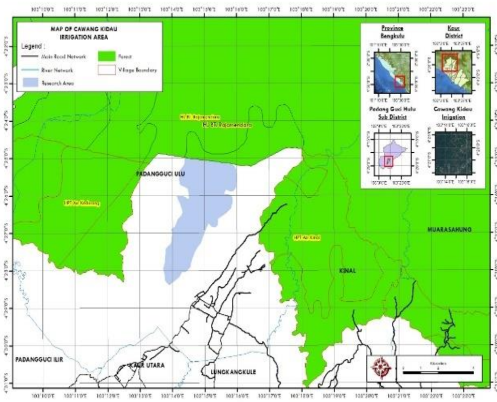
Shallot could be grown in the wide range of agroecological conditions (Rahim, 2012) and technologically this crop could be planted in the lowlands both on the drained wetlands and dry lands in fact most farmers prefer to cultivate the shallot on the irrigated dry lands (Nadeak, 2013). Expansions agricultural development should consider soil characteristics and land qualities for shallot cultivation in new opened areas (Sys *et al.*, 1991). Land utilities for agricultural developments depend on land suitability and land capability for certain crops in order to gain the high productivities, on the other hand, not all areas could be cultivated in high productivities for the certain crops (Bandyopadhyay *et al*., 2009). Furthermore, when the high qualities of the agricultural lands were cultivated in the poor order, the land productivities could be deteriorated in short time and the whole closed ecosystems faced with environmental degradation. For that reason, the land suitability evaluations were important in the agricultural development planning. The land suitability analysis could be used for the agricultural development planning and decisions considering some interactions among location areas, action planning, and environmental components in order to reach optimal and efficiencies when deciding the most suitable area for the agricultural development (Collins *et al*., 2001).

Researches, developments and cultivations for shallot in Bengkulu Province especially in Kaur District are very limited. For example, in 2019, the shallot cultivation in Bengkulu Province only planted in the areas were about 105 ha to produce only about 523.4 tons with very low productivities or about 4.985 tons ha-1, unfortunately in Kaur District was no shallot cultivation (BPS-Statistics Bengkulu, 2021). The researches about land suitable evaluation and cultivations for shallot were much conducted (Sianturi and Simanungkalit, 2017; Susilawati *et al*., 2019; Oktavia *et al*., 2019; Prasetyo *et al.,* 2020) in other areas with specific agroecological circumstances, however the study about the land suitability classification for shallot cultivation in Kaur District, Bengkulu Province until now is no information. Therefore, it is important to conduct land suitability evaluation for shallot cultivation and development in Kaur District especially on the Cawang Kidau irrigation area, Kaur District.

The objectives were to determine the current land suitability classes and to look for technological efforts to improve the suitability classes for shallot cultivation at the Cawang Kidau irrigated area in Kaur District, Bengkulu Province.

Materials and methods

The study area for the evaluation of land suitability classes for shallot cultivation at Cawang Kidau irrigation area, Kaur District, Bengkulu Province was shown in Figure 1. The study area covered about 1,325.25 ha lying on $103^0$13' – $103^0$16' E and $4^0$24' – $4^0$29' S. This study was conducted from June to August, 2022. Soil analysis and mapping preparation were conducted at the Soil Science Laboratory, Faculty of Agriculture, University of Bengkulu. This research was carried out by a descriptive exploratory survey method, with an analysis unit of the Land Mapping Unit (LMU). The LMU was obtained from the results of overlaying of the land units and slope map using ArcGIS 10.3 to get 11 LMU. The determination of soil sample points using purposive sampling technique (Figure 2).



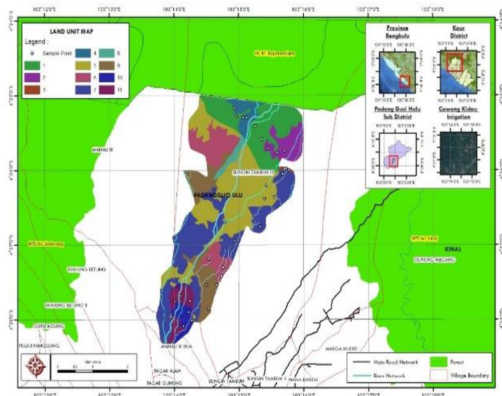


Figure 1. Research location **Figure 2.** Soil sample point on LMU

Agro-climatic data such as temperature were obtained from BPS Statistics-Bengkulu (2022) and mean annual rainfall from Paski *et al*. (2017). The soil samples collected from the field were then air-dried and sieved using a soil sieve Ø 2 mm and Ø 0.5 mm, followed by analysis of soil physical and chemical characteristic. The soil characteristics and land quality included texture (Jensen *et al*., 2017), cation exchange capacity (CEC) (Aprille and Lorandi, 2012), base saturation, pH H_2O (Kalra, 1996), organic C (Nelson and Sommers, 1996), total N (Nelson and Sommers, 2020), available P (Mechlich, 2008), exchangeable K (Wang dan Scott, 2002) and exchangeable Ca and Mg (Hajek *et al*., 1972). The land suitability class was determined by the matching method between the characteristics of the land and the requirements for shallots in appendix 1 modified from Ritung *et al*. (2011).

Evaluation of the suitable classification for shallot cultivation area using Geographical Information System (GIS) with ArcGIS 10.3. The satellite imageries for the suitable classification analysis were necessary the image with suitable resolutions coverage for zoning and characterization of the land (Setiawan and Yoshino, 2020). In this study, the imagery data used obtained from United States Geological Survey (USGS) involving Landsat 8 Operational Land Imager (OLI) with spatial resolution of 30 x 30 m collecting from year of 2019. The image was orthorectified to a UTM 48 S projection and previously the images were already corrected geometrically by Earth Resource Observation System Data Centre (EROS). The last, the class of the suitable land for shallot cultivation modified used determining with maximum likelihood classification was tested with Kappa coefficient formula with ERDAS tools (Nurwanda *et al*., 2016).

Results

The Cawang Kidau irrigation area lies on 287 m above sea level with various physiographical landscapes from flat to hilly topographical ranges. Spatial feature of the area could be seen in Figure 3. Some locations within the area could not be developed for agricultural cultivation because of limiting factor of slope.

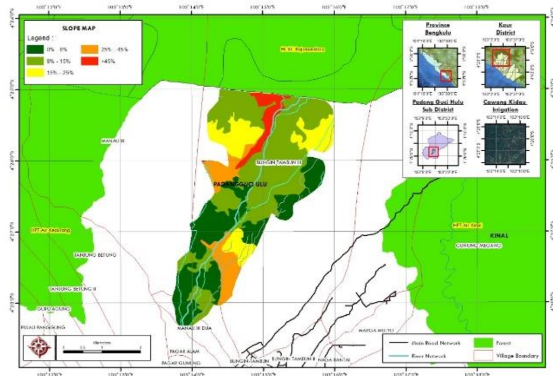


Figure 3. Topographical feature of the area

Agro-climatological conditions in this area involved the maximum temperatures 34.80 ℃ and minimum temperatures 22.00 ℃ with the average 28.7 ^{0}C and the main rainfall 2,871 mm year^{-1}. This mean temperature is classified as moderately sutable (S2) for shallot cultivation however base on rainfall data 1998 – 2016 above, unfortunately this area is categorized unsuitable for shallot cultivation because too much rainfall. Therefore, the mean annual rainfall was not involved as an attribute for evaluation of the shallot suitable determinant.

Current or actual land suitability is a land characteristic generated by ongoing land conditions assessment, without improvement input. From the whole landscapes of the Cawang Kidau irrigation area, 1,325.21 ha, there are 193.48 ha or about 14.60 % are unsuitable for the shallot cultivation because of too steep slope. The spatial distributions of land suitability classes for the shallot cultivation on the Cawang Kidau irrigation area in Kaur District are shown in Figure 4 and Figure 5.

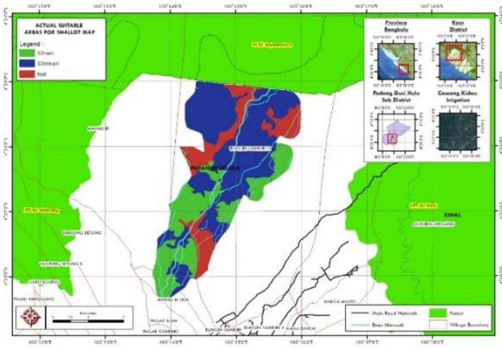


Figure 4. Current Land Suitability Map for shallot

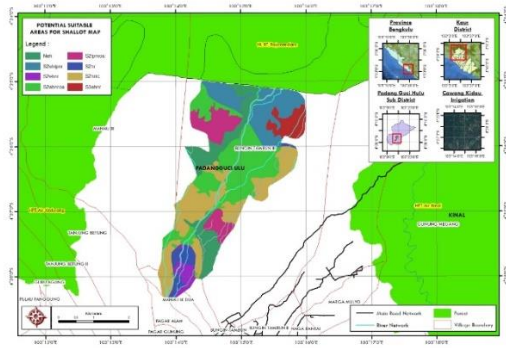


Figure 5. Potential Land Suitability Map for shallot

The actual suitable lands for the shallot cultivation on this area covered about 1,131.73 ha or about 85.40 % from whole area however there is no land in the Cawang Kidau irrigation area categorized in S1 (Highly Suitable) and S2 classes (Moderately Suitable). The actual and potential suitability classes for the shallot cultivation on the Cawang Kidau irrigation area are summarized in Table 1.

Table 1. Land evaluation summaries of actual and potential suitability for shallot

LMU	Actual Suitability	Potential Suitability	Area (ha)
1	S3ehnanr	S2ehlpnr	202.14
2	S3ehnanr	S2ehnr	65.08
3	S3nanr	S2nr	3.13
4	Neh	Neh	43.47
5	S3ehnanr	S2ehnr	348.88
6	S3ehnanr	S2lpnr	124.45
7	S3nanr	S2nrrc	303.84
8	Neh	Neh	20.80
9	Neh	Neh	129.21
10	S3ehnanr	S2ehnr	37.03
11	S3nanr	S2nr	47.18

Note: eh = erosion hazard, na = nutrient availability, nr = nutrient retention, lp = land preparation.

The actual suitable classes for shallot cultivation on LMU 1, LMU 5, LMU 6, and LMU 10 are classified on marginally suitable S3ehnanr which the width area of 777.58 ha have erosion hazard, nutrient availability, and nutrient retention as limiting factors. These lands units of lay on the slope of 8 – 25 % with low to very low nutrient available P and exchangeable K, and nutrient retention because of low pH and low base saturation. The other marginally suitable S3nanr classes involving LMU 3, LMU 7, and LMU 11 cover of 354.15 ha lying on the slope of 0 – 8 % with the limiting factors are low to very low available P and exchangeable K, and nutrient retention due to low soil pH and low base saturation. While, LMU 4, LMU 8, LMU 9 covering areas of 193.48 ha are categorized as unsuitable classes for shallot cultivation because of these land units lay on steep slopes of higher than 25 %. These unsuitable areas are prone to soil degradation because of erosion detachment.

The current or the actual suitable classes of marginally suitable S3ehlpnr with the areas of 777.58 ha for shallot cultivation could be improved to moderately suitable S2ehlpnr on LMU 1 with the areas of 202.14 ha, S2ehnr on LMU 2, LMU 5, LMU 10 with the areas of 450.99 ha, S2lpnr on LMU 6 with the areas of 124.45 ha. Also, from the actual S3nanr could be improved to potential moderately suitable S2nr on LMU 3, LMU 11 with the areas of 50.31 ha, S2nrrc on LMU 7 with the areas of 303.84 ha.

Discussion

Most land units in the Cawang Kidau irrigation area covering 1,131.73 ha or about 85.40 % from whole area could be developed as shallot cultivation areas although there is no land is categorized in S1 (Highly Suitable) and S2 classes (Moderately Suitable). These suitable land units for shallot cultivation are classified as marginally suitable classes with one of the limiting factors is slopes. Also, some locations within the area could not be developed for agricultural cultivation because of the limiting factor of steeper slopes. The main problem of irrigation canals construction on steep slopes was related to financial cost which on the stepper slope required the higher cost to construct the irrigation canals (Perez, 2005). Also, the soils are easily eroded due to a high frequency of heavy rains of the area having a slope greater than 8%; marked relief, 45% (Gioia *et al*., 2021). Tropical areas are more vulnerable because intensive climatic regimes, the soils are fragile and conservation practices are quite limited (Luvai *et al*., 2020).

In fact, most land units in this area covering with flat to undulating physiographical landscapes therefore those are suitable for agricultural activities due to these lands had been built with irrigation canals. With continuously water available through the year because of the water supply from the irrigation facilities, the suitable landscapes covering this area favour for intensive rice cultivation therefore technologically the shallot cultivation also could be developed on this irrigated dry lowland. Most farmers in fact preferred to cultivate the shallot on the irrigated dry lands (Haryani *et al*., 2021). Generally, from the areas of 1,131.73 ha previously classified as marginally suitable for shallot cultivation could be improved to be moderately suitable with various agricultural technological inputs especially introduced terrace construction for step slope of 8 – 25 %, ameliorated soil pH and low base saturation with limes, low nutrient available with nitrogen, phosphor, and potassium fertilizer applied. High acidity level and low nutrient availability are the most challenging factors of shallot production (Sopha *et al.,* 2021a). Futhermore, acid soils have several limitations such as low of phosphorus and base cations availability and high concentration of aluminium and manganese that induce essential nutrient deficiency and acidic toxicity. The acidic soils with having low concentration of base cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) inhibited the essential nutrient uptake and caused a nutrient deficiency and when the shallot underwent deficiency on essential elements could decrease vegetative growth, bulb size and bulb yield (Khokhar, 2019). Futhermore, the limitation of essential nutrients, especially phosphorus and potassium, altered plant physiology that inhibited the rate of growth and could decrease crop yield.

Some strategic actions to improve land quality are giving organic and chemical fertilizer, applying agricultural lime to stabilize soil pH, increasing Cation Exchange Capacity (CEC), and implementing conservation techniques on the steep area by building terrace (Napitupulu *et al.,* 2021). Shallot yield is lower in acidic soils and under low soil P status (Sopha *et al*., 2021b). Futhermore, increasing shallot bulb yield can be achieved by improving the soil fertility of acidic soils. Macronutrient ertilization was necessary to supply the nutrients and support the plant growth. In order to produce 15 tons ha^{-1}, shallots absorbed 110 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1}, and 106 kg K_2O ha^{-1} (Shopa *et al.*, 2015). Liming materials become necessary to improve the soil properties and to achieve the optimum yield. Shallot has shallow and hairless roots that make it susceptible to very acidic soil situation when the plant available-P was limited while high concentration of exchangeable acidity is toxic for the crop therefore lime materials in form of dolomite increased plant growth through increasing soil pH that improved the root growth (Handayaningsih *et al.,* 2020).

The Cawang Kidau irrigation area actually potential for expansion shallot cultivation in Bengkulu. From the areas of 1,325.21 ha, there are 1,131.73 ha classified as marginally suitable for shallot cultivation with various limiting factors such as low nutrient availabilities especially phosphor and potassium, nutrient retention because of low soil pH and base saturation, and erosion hazard due to step slopes. Introducing agricultural technologies such as fertilizers applied, amelioration with limes, and terraces constructions, the current marginally suitable classes could be increased in moderately suitable for shallot cultivation on this area.

Acknowledgements

The author is grateful to DRTPM, Direktur Jenderal Pendidikan Tinggi, Riset, dan Teknologi, Kementerian Pendidikan, Kebudayaan, Riset dan Teknologi, Indonesia for the fund provided through the 2022 PDD Research Scheme (Grant Number 105/E5/PG.02.00.PT/2022, May 10, 2022).

References

Al Rosyid, A. H., Viana, C. D. N. and Saputro, W. A. (2021). Application of Jenkins Box Model (Arima) for consumer price estimation of shallot in Central Java Province (*in Indonesian Language*). Agri Wiralodra, 23:29-37.

Aprille, F. and Lorandi, R. (2012). Evaluation of cation exchange capacity (CEC) in tropical soils using four different analytical methods. Journal of Agricultural Science, 4:278-289.

Bandyopadhyay, S., Jaiswal, R. K., Hegde, V. S. and Jayaraman, V. (2009). Assessment of land suitability potentials for agriculture using a remote sensing and GIS based approach. International Journal of Remote Sensing, 30:879-895.

BPS Statistics Bengkulu (2022). Harvesting Areas of Vegetable and Annual Fruits in Bengkulu Province, 2019-2021 (*in Indonesian Language*). BPS Provinsi Bengkulu. Retried from https://bengkulu.bps.go.id/

BPS Statistics Indonesia (2021). Vegetable Production 2021 (*in Indonesian Language*). Retried from https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html

Collins, M. G., Steiner, F. R. and Rushman, M. J. (2001). Land-use suitability analysis in the United States: historical development and promising technological achievements. Environmental Management, 28:611-621.

Gioia, D., Amodio, A. M., Maggia, A. and Sabia, C. A. (2021). Impact of land use changes on the erosion processes of a degraded rural landscape: An Analysis Based on High-Resolution DEMs, Historical Images, and Soil Erosion Models. Land, 10:673.

Hajek, B. F., Adam, F. and Core, Jr. J. T. (1972). Rapid determination of exchangeable bases, acidity, and bases saturation for soil characterization. Soil Science Society of America Journal, 36:436-438.

Handayaningsih, M., Pujiwati, H., Nasution, D. P. P. and Marwanto (2020). Improving yield and performance of shallot on ultisol through application of dolomite and chicken manure. Advances in Biological Sciences Research, 13:310-313.

Haryani, D., Hadiatry, M. C., Yuniarti, S. and Purba, R. (2021). Improvement of shallots (Allium ascalonicum) cultivation on paddy fields to increase shallots yields and farmers' income during the Covid-19 pandemic. IOP Conference Series: Earth and Environmental Science 715:012018. https://iopscience.iop.org/article/10.1088/1755-1315/715/1/012018

Hasri., Zakaria, J. and Arifin. (2020). The factors determined shallot production in East Banggae, Majene District (*in Indonesian Language*). Paradoks: Jurnal Ilmu Ekonomi, 3:64-72.

Indonesian Ministry of Agriculture (2020). Shallot Outlook 2019. Portal Epublikasi Pertanian. Kementerian Pertanian Republik Indonesia. Retried from http://epublikasi.pertanian.go.id/arsip-outlook/76-outlook-hortikultura/730-outlook-bawang-merah-2019

Jensen, J. L., Schjenning, P., Watts, C. W., Christensen, B. T. and Munkholm, L. J. (2017). Soil texture analysis revisited: Removal of organic matter matters more than ever. PLOS one, 1-10.

Kalra, Y. P. (1996). Soil pH: First soil analysis methods validated by the AOAC International. Journal of Forest Research, 1:61-64.

Khokhar, K. M. (2019). Mineral nutrient management for onion bulb crops – a review. The Journal of Horticultural Science and Biotechnology, 94:703-717.
Khorasgani, O. A. and Pessarakli, M. (2019). Evaluation of cultivation methods and sustainable agricultural practices for improving shallot bulb production – a review. Journal of Plant Science, 43:148-163.
Kiloes, A. M., Hardiyanto., Sulistyaningrum, A. and Syah, M. J. A. (2018). Strategy for shallot agribusiness development in Solok District (*in Indonesian Language*). Horticulture Journal, 28: https://media.neliti.com/media/publications/277026-none-412de1e6.pdf
Luvai, A. K., Obiero, J. P. O. and Omuto, C. T. (2020). Methods for Erosion Estimates in Assessment of Soil Degradation: A Review for Catchments in Kenya. International Journal of Engineering Research & Technology, 9:489-494.
Mechlich, A. (2008). Mechlich 3 soil test extractant: A modification of Mechlich 2 extractant. Communications in Soil Science and Plant Analysis, 15:1409-1416.
Nadeak, T. H. (2013). Comparison of production cost and shallot productivity on wet rice field and dry land through rotation and non rotation cultivation system) (*in Indonesian Language*). Jurnal Ilmu Kesejahteraan Sosial, 12:48-54.
Napitupulu, D., Nurzannah, S. E. and Siagian, D. R. (2021). Sustainable shallot production achievement through analyzing the land suitability and introducing the proper agronomic cultivation practices in samosir regency. IOP Conference Series: Earth and Environmental Science, 807:022073. https://iopscience.iop.org/article/10.1088/1755-1315/807/2/022073/meta
Nelson, D. W. and Sommers, L. E. (1996). Total carbon, organic carbon, and organic matter. Methods of Soil Analysis: Part 3 Chemical Method, 5,3. SSSA Book Series. Retried from https://doi.org/10.2136/sssabookser5.3.c34
Nelson, D. W. and Sommers, L. E. (2020). Total nitrogen analysis of soil and plant tissue. Journal of Association of Official Analytical Chemists, 63:770-778.
Novita, D., Asaad, M. and Rinanda, T. (2019). Potency and opportunity for development centre of shallot cultivation in North Sumatera Province (*in Indonesian Language*). Agrica, 12:92-102.
Nurwanda, A., Zain, A. F. M and Rustiadi, E. (2016). Analysis of land cover changes land landscape fragmentation in Batanghari Regency, Jambi Province. Procedia - Social and Behavioral Sciences, 227:87-94.
Oktavia, Y., Yartiwi. and Damiri, A. (2019). Growth performance and farming feasibility from three varieties of shallot: Case study in Selupu Rejang Sub-District, Rejang Lebong District, Bengkulu Province (*in Indonesian Language*). Jurnal Ilmu-Ilmu Pertanian Indonesia, 21:103-107.
Paski, J. A. I., Sepriando, A., Faski, G. I. S. L. and Handoyo, M. F. (2017). Oldeman Classification of Agroclimate Mapping in Bengkulu Province Based on Ground Observation and Multisatellite data (TMPA and IMERG). Seminar Nasional Penginderaan Jauh ke-4. Retried from http://sinasinderaja.lapan.go.id/files/sinasja2017/prosiding/57_PEMETAAN%20AGROKLIMAT%20KLASIFIKASI%20OLDEMAN%20DI%20PROVINSI%20BENGKULU%20MENGGUNAKAN%20DATA%20OBSERVASI%20PERMUKAAN%20DAN%20MULTI%20SATELIT%20(TMPA%20DAN%20IMERG).pdf
Perez, Z. G. (2005). Appropriate designs and appropriating irrigation systems. Irrigation infrastructure development and users' management capability in Bolivia. Wageningen University. Wageningen. https://edepot.wur.nl/38938
Prakoso, K. I. (2021). Affecting Factors of Shallots Production Level in Wanasari Sub-District Brebes Regency. Business and Economic Analysis Journal, 1:27-37.
Prasetyo., Setyowati, N., Nurjanah, U., Marlina, Y. and Chozin, M. (2020). Growth respons and yield of shallot (*Allium ascalonicum* L.) related to coffee husk composted and nitrogen through different dose (*in Indonesian Language*). Gontor AGROTECH Science Journal, 6:35-54.

Purbiati, T. (2012). Potency of shallot cultivation on peatlands (in Indosian Language). Jurnal Litbang Pertanian, 31:113-118.

Putri, I. P., Arifin, B. and Murniati, K. (2021). Income analysis and technical efficiencies of shallot cultivation in Gunung Alip Sub-District Tanggamus District Lampung Province (in Indonesian Language) Journal of Agribusiness Science, 9:62-69.

Rahayu., Mujiyo and Arini, R. U. (2018). Land suitability evaluation of shallot (*Allium ascalonicum* L.) at production centres in Losari District, Brebes. Journal Of Degraded and Mining Lands Management, 6:1505-1511.

Rahim, A. (2012). Productivity, Quality and Potency for Agroindustry Development of the Lembah Palu Shallot Variety, Central Sulawesi *(in Indonesian Language*). *Disertation.* Postgraduate Program, Hasanudin University. Retried from http://digilib.unhas.ac.id/uploaded_files/temporary/DigitalCollection/NmE2MjhjZGIxZDYwODVjZmIwNjEyZmY1NGQ2MmM2YzU2OGE0ZmEyMQ==.pdf

Ritung, S., Nugroho, K., Mulyani, A. and Suryani, E. (2011). Technical Refference of Agricultural Land Evaluation. Research and Development Centre for Agricultural Land Resource. Balitbangtan. Bogor. Retried from https://bbsdlp.litbang.pertanian.go.id/ind/index.php/publikasi-3/petunjukteknis? download=20:evaluasi-lahan-untuk-komoditas-pertanian

Setiawan, Y. and Yoshino, K. (2020). Spatial modelling on land use change in regional scale of Java Island based-on biophysical characteristics. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan, 10:511-523.

Shopa, G. A., Rosliani, R., Basuki, R. S., Liferdi, L. and Yufdy, M. P. (2015). Correlation of plant nutrients uptake with shallot production in alluvial soils. Advances in Agriculture & Botanics- International Journal of the Bioflux Society, 7:127-137.

Sianturi, D. and Simanungkalit, N. M. (2017). Land suitability analysis for shallot in Pasaran Village, Nainggolan Sub-District, Samosir District (*in Indonesian Language*). Jurnal Geografi, 9:141-150.

Sopha, G. A., Effendi, A. M., Aprianto, F. and Firmansyah, A. (2021a). The incorporation of lime and NPK fertilizer on shallot production in peat soil. IOP Conference Series: Earth and Environmental Science, 653:012057.

Sopha, G. A., Hermanto, C., Hanly, J., Heyes, J. and Kerckhoffs, H. (2021b). Influence of lime and phosphorus fertilizer on shallot growth and bulb yield in strongly acid soils in West Java, Indonesia. Acta Horticulturae, 1312:315-322.

Sulistyaningsih, E., Pengestuti, R. and Rosliani, R. (2020). Growth and yield of five prospective shallot selected accessions from true seed of shallot in lowland areas. Ilmu Pertanian (Agriculture science), 5:92-97.

Susilawati, D. M., Maarif, M. S., Widiatmaka and Lubis, I. (2019). Land evaluation and land available for shallot cultivation in Brebes District Central Java Province (*in Indonesian Languag*e). Journal of Natural Resources and Environmental Management, 9:507-526.

Sys, C., Ranst, E. van. and Debaveye, J. (1991). Land evaluation Part 1: Principle in land evaluation and crop production calculations. Agricultural Publication, 7. https://library.wur.nl/WebQuery/isric/2279534

Tsagaye, D., Ali, A., Wegayehu, G., Gebretensay, F., Fufa, N. and Fikre, D. (2021). Evaluation of True Seed Shallot Varieties for Yield and Yield Components. American Journal of Plant Biology, 6:19-22.

Wang, J. J. and Scott, A. D. (2002). Determination of exchangeable potassium in soil using ion selective electrodes in soil suspensions. European Journal of Soil Science, 52:143-150.

(Received: 15 August 2022, accepted: 30 October 2022)

Appendix 1. Land suitability class for shallot

Soil characteristics/ Land quality	Land suitability class			
	S1	S2	S3	N
Temperature (tc)				
Mean temperature (^{0}C)	25 - 28	28 – 31 23 - 25	31 – 33 21 – 23	>33 < 21
Water available (wa)				
Mean annual rainfall (mm yr^{-1})	1000 - 1400	900 – 1000 1400 – 1700	800 – 900 1700 - 2500	<800 >2500
Oxygen availability (oa)				
Drainage	Well drained, somewhat poorly	Somewhat excessive, moderately	Poorly drained	Very poor, excessive drained
Rooting condition (rc)				
Texture	Moderately fine	Fine	Moderately coarse, very fine	Coarse
Coarse material (%)	>15	15 – 35		>55
Soil depth (cm)	>50	30 – 50	35 – 55 20 – 30	<20
Nutrient retention (nr)				
Soil CEC (cmol kg^{-1})	>35	20 – 35	<20	
Base saturation (%)	>35	20 – 35	<20	
pH	6,0 – 7.5	5.5 – 6.0 7.5 – 8.0	<5.5 >8.0	
C-organic (%)	>2	0.8 – 2.0	<0.8	
Nutrient availability (na)				
N-total (%)	Moderate	Low	Very low	
P_2O_5 (mg 100g^{-1})	High	Moderate	Low to very low	
K_2O (mg 100g^{-1})	Moderate	Low	Very low	
Erosion hazard (eh)				
Slope (%)	<3	3 – 8	8 – 25	>25
Erosion hazard		Very low	Low to moderate	Heavy to very heavy
Land preparation				
Rock on the surface (%)	<5	5 – 15	15 – 40	>40
Rock outcrop (%)	<5	5 – 15	15 – 25	>25

Appendix 2. Soil characteristics and land quality classes for shallot cultivation suitabilities

Soil Characteristic/ Land Quality	**LMU 1**	**LMU 2**	**LMU 3**	**LMU 4**	**LMU 5**	**LMU 6**	**LMU 7**	**LMU 8**	**LMU 9**	**LMU 10**	**LMU 11**
Temperature (tc)											
Mean temperature (^{0}C)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)	28.25 (S2)
Water availability (wa)											
Mean annual rainfall (mm yr-1)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)	2,871 (N)
Oxygen availability (oa)											
Drainage	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)	Well drained (S1)
Rooting condition (re)											
Texture	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate		Moderate	Moderate	Moderate
Coarse material (%)	12 (S1)	5 (S1)	10 (S1)	10 (S1)	15 (S1)	10 (S1)	15 (S1)		10 (S1)	14 (S1)	10 (S1)
Soil depth (cm)	70 (S1)	55 (S1)	55 (S1)	61 (S1)	80 (S1)	60 (S1)	70 (S1)		60 (S1)	60 (S1)	65 (S1)
Nutrient retention (nr)											
CEC (Cmol kg-1)	13.79 (S2)	18.81 (S1)	16.00 (S1)	22.21 (S1)	17.46 (S1)	10.04 (S2)	14.15 (S2)		9.75 (S2)	25.41 (S1)	9.96 (S2)
Base saturation (%)	8.21 (S3)	5.15 (S3)	6.74 (S3)	5.54 (S3)	4.02 (S3)	7.87 (S3)	6.33 (S3)		9.82 (S3)	4.58 (S3)	10 (S3)
pH	4.5 (S3)	4.5 (S3)	5.19 (S3)	4.37 (S3)	4.05 (S3)	4.35 (S3)	4.35 (S3)		4.37(S3)	4.65(S3)	4.6 (S3)
C-organic (%)	4.37 (S1)	6.23 (S1)	4.06 (S1)	6.23 (S1)	5.73 (S1)	3.83 (S1)	5.07 (S1)		4.68(S1)	7.19(S1)	4.53(S1)

Soil Characteristic/ Land Quality	LMU 1	LMU 2	LMU 3	LMU 4	LMU 5	LMU 6	LMU 7	LMU 8	LMU 9	LMU 10	LMU 11
Nutrient availability (na)											
Total N (%)	0.24 (S1)	0.4 (S1)	0.29 (S1)	0.36 (S1)	0.39 (S1)	0.32 (S1)	0.33 (S1)		0.29(S1)	0.49(S1)	0.34 (S1)
P2O5 (mg 100g^{-1})	8.95 (S3)	5.61 (S3)	5.01 (S3)	8.57 (S3)	7.44 (S3)	8.12 (S3)	7.28 (S3)		6.15 (S3)	5.99 (S3)	7.97 (S3)
K2O (cmol kg^{-1})	0.74 (S3)	0.56 (S3)	0.55 (S3)	0.61 (S3)	0.38 (S3)	0.44 (S3)	0.36 (S3)		0.54 (S3)	0.54 (S3)	0.56 (S3)
Erosion hazard (eh) Slope (%)	8 – 15 (S3)	15 – 25 (S3)	0 – 8 (S1)	>45 (N)	8 – 15 (S3)	15 – 25 (S3)	0 – 8 (S1)	>45 (N)	25 – 45 (N)	8 – 15 (S3)	0 – 8 (S1)
Erosion hazard	-										
Land preparation											
Surface stoniness (%)	10 (S2)	0 (S1)	0 (S1)	10 (S2)	0 (S1)	5 (S2)	0 (S1)		10 (S2)	0 (S1)	0 (S10
Surface outcrop (%)	0 (S1)	0 (S1)	0 (S1)	0 (S1)	0 (S1)	5 (S2)	0 (S1)		0 (S1)	0 (S1)	5 (S1)
Actual land suitability class	S3ehnanr	S3ehnanr	S3nanr	Neh	S3ehnanr	S3ehnanr	S3nanr	Neh	Neh	S3ehnanr	S3nanr
Limiting factors	Erosion hazard, nutrient available, nutrient retention	Erosion hazard, nutrient available, nutrient retention	Nutrient available, nutrient retention	Erosion hazard	Erosion hazard, nutrient available, nutrient retention	Erosion hazard, nutrient available, nutrient retention	Nutrient available, nutrient retention	Erosion hazard	Erosion hazard	Erosion hazard, nutrient available, nutrient retention	Nutrient available, nutrient retention
Technological practice overcoming the limiting factors	Applied terrace, fertilizers, liming	Applied terrace, fertilizers, liming	Applied fertilizers, liming		Applied terrace, fertilizers, liming	Applied terrace, fertilizers, liming	Applied fertilizers, liming			Applied terrace, fertilizers, liming	Applied fertilizers, liming
Potential land suitability class	S2ehlpnr	S2ehnr	S2nr	Neh	S2ehnr	S2lpnr	S2nrrc	Neh	Neh	S2ehnr	S2nr