Computer Assisted Learning on Aridity Disaster Learning Using SIMIA (Satellite Imagery for Modelling Index of Aridity)

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Abstract. The purpose of this study is to develop Computer Assisted Learning (CAL) to identify aridity using Satellite Imagery Modelling Index of Aridity (SIMIA) media. SIMIA is a system used to model area of aridity by using of rainfall data from observation of rain and vegetation index extracted by satellite image of LANDSAT 8 OLI and Google Satellite. SIMIA learning planning is performed using procedures of Analyzed, Standardized, Strategy, Utility, Require, and Evaluate (ASSURE). The results show that the ASSURE learning plan is more systematic, it attracts the attention of the participants; it can illustrate the goal to be achieved as determined by the learning achievements. The SIMIA CAL learning plan using ASSURE allows for the selection and delivery of appropriate, timely (pedagogical) content, the use of technology is appropriate to the needs of learners (technology) and the interaction is created between learners and instructors.

1. Introduction

Computer Aided Learning or Computer Assisted Learning (CAL), is a computer-based learning and presented with multimedia (textual, visual, sound, and movement media) or referred to as digital multimedia [1]. CAL was originally designed as a learning tool for interface in the classroom but over time in line with its development CAL has become a factor to support the fulfilment of learning achievement [2]. CAL has been widely applied in various scientific disciplines, including biology, mathematics, medicine, dentistry, veterinary medicine, physiotherapy, geography and remote sensing [1][3][4][5]. The objectives of CAL utilization are: (1) improving the ability of critical thinking and problem solving skills independently; (2) encouraging the learning process to take more responsibility in the selection, control and evaluation of independent learning activities anytime, anywhere, and in any method, (3) delivering of information in the form of knowledge, skills, and attitudes of participants so that they can adjust their thoughts, feelings, and willingness to learn in more directed and controlled[2][4][6]. This study aims to develop aridity disaster learning using CAL media for Field Climate School (in Indonesia called Sekolah Lapang Iklim or SLI) participants organized by Meteorology Climatology and Geophysics Agency (in Indonesia called BMKG) of Central Java Province and Filed Agriculture Advisor in Food Security Agency (In Indonesia called Badan Ketahanan Pangan) of Boyolali Regency. Aridity is a natural phenomenon that occurs slowly from monthly, seasonal and annual periods with unpredictable duration, and cross-sectorial impact. Aridity is characterized by prolonged water shortages, ecological resource damage, reduced agricultural production, and famine, and casualties [7]. It is estimated that 3 million Indonesians live below the poverty line in drought-affected areas between October and December 2016, 1.2 million of which depend on rainfall for the livelihoods of the food production in agricultural sector. In order for the learning process to take place effectively, efficiently and fun so
that the learning objectives are achieved, the learning model ASSURE is applied. ASSURE is a systematic procedure for designing instructional learning with computer application media. It is hoped that by using appropriate learning model, the information can be disseminated more precisely to the target, increasing the motivation and appealing to the learners[8]. Learning media CAL of drought disaster used is Satellite Imagery Modeling Index of Aridity (SIMIA). SIMIA is a system used to model aridity of area by using rainfall data from rain observation and vegetation index extracted by LANDSAT 8 OLI and Google Satellite image. SIMIA is the development of one of the modules in the Pranatamangsa System (Traditional Weather Forecast System) which has already been applied in Field Climate School activities [9].

2. Theoritical Background

2.1. CAL SIMIA Module

SIMIA is an application developed with an aim to classify and model the aridity level of a region based on Geographic Information System. SIMIA was developed using the R package Shiny programming in R Studio. SIMIA is composed of two models of aridity classification: (1) Standardized Precipitation Index (SPI) model and Vegetation Indices (VI) model. The SPI model uses long-term rainfall data to see the probability patterns of distribution and trends so that it needs a uniform number of observed rainfall stations throughout the region [10][11]. Model VI is a solution to the limited number of rainfall stations because it uses satellite imagery data. Satellite image data provides continuous, consistent, and timely information of parametric, hydrological and biophysical parameters over large areas and long periods of time using the dryness index. Measurements of vulnerability, risk mapping and aridity risk mitigation in VI use surface data of earth vegetation [12][13]. The World Meteorology Organization (WMO) body sets a drought level indicator using satellite imagery including the Enhanced Vegetation Index (EVI), the Evaporative Stress Index (ESI), the Normalized Difference Vegetation Index (NDVI), the Temperature Condition Index (TCI), the Vegetation Condition Index (VCI), Vegetation Drought Response Index (VegDRI), Vegetation Health Index (VHI), Water Requirement Satisfaction Index (WRSI and Geo-spatial WRSI), Normalized Difference Water Index (NDWI) and Land Surface Water Index (LSWI), Combined Drought Indicator (CDI), Global Land Data Assimilation System (GLDAS) [18]. Visualization of drought index information on SPI and VI is as presented in Figure 1 (a) and (b).

![Figure 1](a) Visualization of SPI model and (b) VI model in SIMIA application

The mathematical functions used for the analysis, visualization and interpretation of information in SIMIA are SPI, Spatial Autocorrelation, Nearest Neighbor, and Standardized Precipitation Index functions [14]. SPI is determined by statistical probabilistic method of gamma distribution to find the frequency or probability of density with equation [15] :

\[
g(x) = \frac{1}{\beta \alpha \Gamma(\alpha)} x^{(\alpha - 1)} e^{-\frac{x}{\beta}} \text{ for } x = 0
\]

Which is \( \alpha > 0 \) the form parameter, \( \beta > 0 \) is the scale parameter, \( x > 0 \) is the amount of rainfall.

\[
\Gamma(\alpha) = \int_{0}^{\infty} y^{\alpha - 1} e^{-y} dy \text{ where } \Gamma(\alpha) \text{ is gamma function } \alpha = \frac{1}{4\beta} \left(1 + \frac{1 + 4\beta}{3}\right) \text{ for } \beta = \frac{\beta}{\beta}
\]

Which is \( A = \ln(x) - \frac{1}{n} \sum \ln(x) \) and \( n \) is the amount of rainfall. Rainfall is calculated by the equation:

\[
G(x) = \int_{0}^{x} g(x)d(x) = \frac{1}{\beta \alpha \Gamma(\alpha)} \int_{0}^{x} x^{\alpha - 1} e^{-\frac{x}{\beta}} dx = \frac{1}{\Gamma(\alpha)} \int_{0}^{x} t^{\alpha - 1} e^{-t} dt
\]

The SPI calculation results are interpolated to see the distribution of rain across the study area by:
Which $Z(S_0)$ is the predicted value for point $(S_0)$, $N$ is the number of sample points to be calculated around the predicted value location, $\lambda_i$ is the weight assigned for each calculated point, and $Z(S_i)$ is the value observed around $S_i$ location. Weighting is a function that is inversely proportional to the distance, the farther the distance of an observation location the smaller the weight. The determination of the weight is by equation (6) [16].

2.2. The Learning Concept of ASSURE

ASSURE is an instructional learning development model used by teachers to plan learning by integrating the usage of technology and media. The ASSURE model was first developed by Heinich, Molenda & Russel in 1993. This model focuses on achieving learning objectives from the learners’ perspective [17]. The ASSURE learning model is structured in 6 stages that include learner, standard and objective, select strategy, technology and media, utilize technology and media, revise and evaluation [6]. The ASSURE model enables the incorporation of various media and technologies for face-to-face learning in the classroom as well as online learning by using interactive textual, image, sound and animation media as well as strict monitoring of learning outcomes to achieve learning objectives [8][18]. This model provides learning facilities by using TIK better for the purpose of learning can be achieved. Learning participants have the opportunity to use media and other learning tools, participate actively, save for independent use and discuss with other learning participants. The learning materials are well designed, attracting the attention of the learners, illustrating the goals to be achieved and providing new materials [18]. The ASSURE model is focused on the design phase of learning, analysis and cycle structure through the incorporation of media and technology.

3. Methods research

The study is conducted using ASSURE stages to plan learning of aridity using SIMIA media. Learning planning stages are done as shown in Figure 2.

![ASSURE Model Diagram](image)

**Figure 2.** Lesson planning with ASSURE

- **1. Analyze Learners**
  - Education Background
  - Current Knowledge
  - Cultural & Ethnic
  - Economic & Social Learners

- **2. Standard & Objective**
  - Curriculum & Learning Outcome
  - Competencies of the learners
  - Action & Behaviors
  - Condition

- **3. Select Strategy, Technology, Media & Materials**
  - Small Group Discussion Methods
  - Computer Assisted Learning
  - Module SIMIA
  - Provide Computer and ICT others

- **4. Utilize Technology, Media & Material**
  - Materials
  - Learning Media & SIMIA application
  - Prepare of Learners
  - Provide The Learning Experiences

- **5. Revise & Evaluate**
  - Evaluation of Learning Methods
  - Evaluation of Learning Media
  - Create rubrics for evaluate learners
  - Learners & Instructor Performance

The stages are:
1. Analyzing Learners, aimed to identify learning participants that include: educational background, mastery of knowledge, Job background and socio-economic community.
2. Standard & Objective aims to develop curriculum and achievement of aridity identification learning.

In this learning process, it is expected that the competency standards, attitude and behavior changes in the framework of disaster risk reduction can be achieved. Standard of aridity identification learning achievement includes: (1) Knowledge of El Nino and La Nino climate changes as well as its relation to drought and its impact on agriculture; (2) Knowledge of aridity monitoring mechanism with SPI and its weakness; and (3) Knowledge of aridity monitoring mechanisms using satellite imagery data.
3. Selection, Strategy, Technology, Media & Materials with an aim to establish the learning method through Small Group Discussion and Computer Assisted Learning using SIMIA.

4. Utility Technology, Media & Materials with an aim to identify how the learning process is conducted, which includes: (1) Introduction of aridity data; (2) Entry rainfall data to SIMIA; (3) SPI analysis & interpretation; (4) Pre-processing of remote sensing data; (5) VI Extraction data; (6) VI analysis & interpretation; and (7) Local wisdom of Pranatamangsa.

5. Revising & Evaluating with an aim to evaluate the learning process that includes: (1) Finding out whether Small Group Discussion learning method is sufficient to meet the needs of knowledge and skills of the participants of learning; (2) Finding out whether the module of SIMIA learning material is sufficient enough to represent the geographic distribution of aridity phenomenon; and (3) Finding out whether the instructor has knowledge, experience and competence in accordance with the needs of fulfillment of learning achievement.

4. Result and Discussion

Aridity learning is needed as an effort to educate people in disaster prone areas with the aim of reducing the risk of drought disaster. The learning model is focused on the three components i.e. participant interaction in learning, pedagogy and technology. Component of interaction is one of the basic characteristics of human who need a social environment. Developing of attitudes and interaction behavior among the participants of learning are ones of the achievements in learning. The pedagogical component is focused on the selection of appropriate content, the use of participant resources and the facilitator during the lesson. The technological component is focused on how the learners can independently utilize the tools, instruments and computer technology tools in learning[19]. Model pembelajaran didesain dengan pendekatan ASSURE. Learning model is designed with ASSURE approach. This learning model is widely applied in the field of Climate Field Schools (SLI).

4.1. Analyzing

a. General Characteristics

Aridity learning activities that is held in SLI activities or similar activities followed by farmer groups and field-technical coaches of the Agricultural Agency. The title of learning is Aridity Identification Index. Learning time is 3 x 60 minutes. Educational backgrounds of participants were very diverse ranging from junior, senior high school and university with age between 25 - 50 years. The participating professions were farmer landowners and agricultural field coaches.

b. Special Characteristics

a. Learning participants have knowledge and skills in agricultural cultivation both as farmers and extension workers.

b. Learning participants have practical knowledge about the climate such as knowledge of local wisdom of pranatamangsa which is useful in agricultural cultivation.

c. Learning participants have the ability to use computers as a SIMIA learning criterion.

d. Aridity disaster material is a natural phenomenon that is cyclic and multidimensional so it requires interesting presentation techniques and studied from the perspective of the participants of learning.

c. The participants', Learning styles are 3 aspects: verbal or linguistic aspect (listening), visual or spatial (observing) aspect and kinaesthetic aspect (practicing).

4.2. Standard & Objective

The standards to be achieved are the basic competencies to be achieved are:

a. Finding out the function of data menu, rainfall sub menu and vegetation index existing in SIMIA application.

b. Finding out the function of the image menu, SPI sub-menu, nearest neighbour and nearest neighbour vegetation index in the SIMIA application.

c. Ability to run the function of every menu and sub menu available in the SIMIA application.

d. Ability to read and interpret information obtained from the SIMIA application.

Learning indicators using SIMIA are:

a. Identifying the data menu, rainfall sub menu and vegetation index and capability to enter new data correctly.

b. Identifying the image menu, SPI sub menu to see the aridity of sub-districts index.
c. Identifying the image menu, nearest neighbor sub menu to see spatial correlation among aridity-stricken sub-districts.
d. Identifying the image menu, sub menu of the nearest neighbor vegetation index to see the aridity index and its interpretation among sub-districts.

Learning Objectives of identification of aridity using SIMIA are:
a. The learning participants know how to determine the aridity index, data requirements used and how the data is obtained.
b. Participants learn to know how to read the results of data processing performed by SIMIA application in the form of tables, graphics and thematic maps.
c. Participants learn how to interpret SPI information and vegetation index used for the preparation of aridity index.

4.3. Selecting of Strategies, Technologies, Media and Materials

Strategies, The strategy chosen for the learning process is Small Group Discussion (SGD) or Computer Assisted Learning (CAL) in accordance with the needs of the learning process. SGD is selected when computers are limited so that the learning participants should be organized into groups which each group has at least 1 computer. CAL is selected if each participant can learn with one computer. Learning is also conducted using Collaborative Learning (CL) to motivate cooperation among participants. Technologies, The technology used for learning is computer, LCD and printer.

4.4. Materials

Teaching materials in the learning process include:

1. Introduction of data aridity, definition of aridity is related to land degradation, forest fires, declining of crop production, social conflict and population migration[20][21][22][23]. Classification of aridity: meteorology, hydrology, agriculture and socioeconomic[10][24].

2. Entry rainfall data to SIMIA, the method of measuring aridity using the SPI method [10] which interpretation of aridity information visualization presented in Figure 3. Figure 3. describes the thematic map of aridity index in (a) dry season and (b) rainy season that in 2010 was at in the value of -1 to 1 which means in moderate aridity condition to near normal condition [10][11][12].

![Figure 3. Visualization of aridity index using SPI method (a) dry season and (b) rainy season](image)

3. SPI Analysis

SPI analysis and interpretation of spatial aridity indices are performed using Inverse Distance Weight (IDW) interpolation, a deterministic interpolation technique developed using statistical models and autocorrelation [16].

![Figure 4. The distribution of rainfall in dry and rainy season](image)
Examples of IDW analysis results in the dry season of June and October 2010 and the rainy season in February and November 2010 are presented in Figure 4. It shows the spread of aridity in the study area that extended during the dry season (June and October) and decreased at rainy season (February and November).

4. Preprocessing of remote sensing data
   1. VI Extraction of data, VI (Vegetation Index) is an arithmetic combination of two or more channels of spectral vegetation characteristic [25]. For example, the measurement method of VI through comparing of light amount of Red with near Near-Infrared received and reflected by chlorophyll. In non-vegetation surface areas, open land, damaged settlements or vegetation, there will be a low vegetation index value compared to areas with high density vegetation and healthy vegetation that will produce a high vegetation index [26].
   2. VI Analysis & Interpretation, VI is a numerical transformation of the spatial variability of vegetation characteristics extracted from remote sensing images by minimizing soil geometry, atmospheric composition and solar effects on sensors [27]. Type VI for the identification of aridity and land fires in SIMIA are NDVI, NDWI, EVI, VSI, NBR [28][29][30][31][32][33][34][24]. For example, the vegetation index in the observation area is in the range of values < 0.5. Among the 124 observation period < 25%, it show that the value of vegetation index approaching 1.0 as shown in Figure 6. The range of vegetation index (IV) with a range of 0.5 < IV < 1.0 is represented as a non-canopy vegetation region such as grass, shrubs and less indicates as barren region.

4.5. Utilizing Technologies, Media and Materials
   1. Previewing the Materials, the instructor prepares teaching materials consisting of complete presentation files and SIMIA application that runs well.
   2. Preparing the Materials, the instructor displays the presentation file and SIMIA application and ensures that the material can be read properly.
   3. Preparing the Environment, The instructor checks the computer readiness for each group or participant, the readiness of SIMIA application installed on computers, and checks a comfortable room for learning.
   4. Preparing the Learners, the instructor introduces learning with an introduction, explains the learning objectives, learning agenda, time sharing and the running learning process. Instructor also delivers targets to be achieved in the learning.
   5. Providing Learning Experience, The instructor conveys the concept of climate anomaly cycles, the concept of aridity and aridity indicators that are easily recognizable. The instructor systematically displays aridity measurements with SPI, reads SPI data and interprets it. The instructor systematically displays aridity measurements with VI, reads VI data and interprets it. The instructor guides learning participants to run SIMIA application, to read data and interpret the resulting information.

4.6. Requirement of Learner Participation
1. The purpose of this stage is to see the participants’ interest and understanding of the material presented, for this reason, discussion was made between the participants of the lesson with the instructor and the discussion was made between the learning groups.

2. Lesson participants were asked to look at the aridity classification in their respective areas and discuss the anticipation to be taken to lower the risk.

4.7. Evaluation & Revision

Evaluation of learning participants is done through an observation sheet that includes information:
1. Finding out whether learners can recognize the occurrence of aridity and its indicators and visions that are recognized visually.
2. Finding out about participant's perspective on aridity disaster and the perceived impacts especially in agricultural cultivation.
3. Finding out about steps and preparations to anticipate when those things occur.

Evaluation of SIMIA learning media is done through feedback sheet of study participants which:
1. Finding out whether SIMIA application can assist people in understanding the aridity cycle and about how to determine the occurrence of aridity and distribution of aridity risk areas.
2. Finding out about information that is needed to improve the scope of analysis and information in the SIMIA application.

Teacher evaluation is done through teacher evaluation sheet that include:
1. Finding out whether teachers have a competence in delivering materials.
2. Finding out whether teachers can answer the field information needs for the learners.
3. Finding out whether teachers have experience in aridity analysis practices in the field.

5. Conclusion

The results show that the risk index of aridity disaster is efficient, targeted and interesting if delivered using SIMAL CAL. CAL SIMIA can simplify how to identify region aridity indices, spatial distribution patterns and spatial connectivity in the form of thematic maps using vector data and Google satellite. SIMIA provides a selection of aridity index information using the SPI method and compares it with the results of analysis VI. ASSURE is an appropriate method for the preparation of the SIMIA CAL learning plan as it is more systematic, it can draw the attention of learners and it can illustrate the goals to be achieved as the learning outcomes are set. By using ASSURE, it is possible to select and deliver appropriate and timely (pedagogical) content, to know the use of technology appropriate to the needs of learners (technology) and to know the interaction created between learners and instructors.

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