CH4 Gas Mitigation Strategy with the Use of Interpretative Structural Modeling Method

Hutwan Syarifuddin[1*], A. Rahman Sy[2], Dodi Devitriano[3]

[1] *Master of Environmental Science Program, University of Jambi*
[2,3]*Faculty of Animal Husbandry, University of Jambi*
**correspondence:08127807950 email: hutwan_syarifuddin@unja.ac.id*

ABSTRACT
Climate change is related to greenhouse gases (GHG), one of the sectors that produces GHG is the livestock sector which comes from enteric fermentation and manure management in the form of CH4, CO2 and N2O. The livestock sector contributes around 18-51% of anthropogenic GHG. The national contribution of GHG emissions from the livestock subsector is around <1.5%, but globally it contributes 12% of total world emissions. This study aims to develop a CH4 gas mitigation strategy in cow manure management based on the ISM (Interpretative Structural Modeling) method. The results of the ISM analysis show that the causes of CH4 gas are: (1) the quality of human resources, (2) the number of livestock, (3) livestock management, (4) limited infrastructure. To mitigate CH4 gas, several strategies are needed, namely (1) providing additional concentrate feed, (2) building a biogas installation and making compost, (3) building good cow shed facilities.
Keywords: *CH_4, ISM, Manure, livestock.*

1. INTRODUCTION

Ruminant livestock is one of the producers of CH4 gas, both derived from enteric fermentation of rumen and from the process of degradation of organic material of livestock manure. CH4 gas produced by livestock depends heavily on the type, age, weight, quality and quantity of feed provided. Ruminant and non-ruminant cattle transmit CH4 gas as a result of digestion and sewage management, while poultry livestock are only from sewage management. CH4 gas produced by livestock greatly affects donations to greenhouse gases (GHG). According to the [1] the agricultural sector accounts for 5% of overall GHG emissions. At least 5 (five) activities from the agricultural sector as a source of GHG are 1) farms; 2) rice cultivation; 3) burning of savannas; 4) burning agricultural waste and 5) agricultural land.

Livestock activities account for 24.1% of total emissions derived from the agricultural sector. Emissions from livestock are derived from the digestive activities of livestock and the management of livestock manure [2]. CH4 gas produced by livestock is 21 times more dangerous than C02 [3]. According to the IPCC [1] CH4 gas emissions derived from one dairy cow amounted to 56 kg CH4/tail/year, beef cattle 44 kg CH4/head/year, buffalo 55 kg CH4/head/year, goat, sheep and horse respectively 8 kg CH4/head/year, 5 kg CH4/head/year and 18 kg CH4/head/year. Meanwhile, CH4 emissions from cattle manure based on the assumption of dried feces amount to 27 kg CH/head/year dairy cows, 2 kg CH4/head/year, buffalo 3 kg CH4/head/year, goat 0.37 kg CH4/head/year, sheep 0.23 kg CH4/head/year and 2.77 kg CH4/head/year. Cattle fed conventional feed and additional feed were able to reduce GHG emissions by 19% [4]. [5] stated that the burden of CH4 gas emissions from enteric fermentation 1.122728 Gg CH4/th, CH4 Emissions from Sewage Management 0.023888 Gg CH4/th.

In an effort to reduce CH4 gas emissions from livestock, there needs to be a feeding strategy and CH4 gas mitigation strategy through the management of livestock waste. According to [6] the higher the amount of low quality feed then the higher CH4 gas production.

In strategizing gas mitigation CH4 can be used interpretative structural modeling (ISM) method [7]. The use of the ISM method in has been carried out by [8] to improve the performance of the supply chain / ISM to model business processes in an organization [9]. Geoge and Pramod, 2014 Mention that ISM helps researchers to; (1) a better understanding, and (2) a clear introduction of what is unknown. ISM to analyze the conversion patterns of rice fields and their causal and prevention relationship structures [10]. Structural models are used to photograph complex subjects of a system with graphic patterns and sentences [11],[12],[13]

The main purpose of the study was to measure CH4 gas from cow manure fed additional concentrate and establish the structure of CH4 gas causation relationship and CH4 gas mitigation strategy. Specifically, the purpose of this study is to compile sub-elements of the causes of CH4 gas and strategy sub-elements for CH4 gas mitigation sourced from cattle manure.

2. METHODS

2.1. Place and Time of Research

Research conducted in Pudak Village Kumpeh Ulu District Muara Jambi Regency. The time of the study was conducted from May to September 2020.

2.2. Materials and Tools

Necessary equipment such as tally Sheet, camera, chamber, thermometer, syringe, dry battery, computer, stop watch, Gas Chromatography, laboratory equipment for analysis of cow manure compost, vials, syringes measuring 10 ml, equipment cages and stationery. Bali cattle farmers as many as 110 people.

2.3. Data Collection Methods

The method of data collection is; (1) survey method, (2) observation method in the field. The types of data used are primary data and secondary data in accordance with the research objectives. Primary data retrieval method using questionnaires. Secondary data from statistics of Jambi Province in Numbers [14] and from various research journals.

The data used for the identification of the cause structure and mitigation of CH4 gas of cattle manure is a sub-element that is the result of focus group discussion (FGD) activities. FGD has the aim of obtaining CH4 gas causative and mitigating factors. The FGD includes representatives from farmers, authorities, village bureaucracies and academics. Sub-elements of FGD results are reinforced by references to previous research results. The cause of CH4 gas in cow manure has 11 sub-elements that are then structured through the opinion of experts. The 11 sub-elements causing the CH4 gas to occur in livestock excrement are; 1) Limited infrastructure (means and infrastructure of cages), 2) Limited business capital, 3) Low quality of farmer's human resources, 4) Low livestock productivity, 5) Low animal feed quality, 6) Livestock maintenance pattern, 7) Limitation of government assistance, 8) Cattle life, 9) Cattle type, 10) Number of livestock, 11) Management of livestock manure.

The sub-element of the CH4 gas mitigation strategy of cow manure produces 7 sub-elements of the strategy namely; 1) Building a good coop facility, 2) Providing additional feed in the form of concentrates, 3) Building biogas installation and compost fertilizer manufacturing, 4) Establishing the health of cattle, 5) Controlling the temperature of the cage, 6) The pattern of animal integration, 7) Utilizing biourine.

3. ANALYSIS DATA

Analysis method to obtain sub- key elements of the cause of CH4 gas from cattle manure and CH4 gas mitigation strategy of cattle manure using ISM whose measures were adopted from [15], [16], [17], [18] that is.

1. Identify the causes and strategies of ch4 gas mitigation from cow manure by conducting a Focus Group Discussion (FGD). FGD was implemented on June 15, 2020.
2. Summarizes FGD results and combines them with literature reviews to produce key elements and sub-elements of CH4 gas mitigation causes and strategies.
3. Determine the contextual relationship of CH4 gas causes and mitigation strategies.
4. Develop a matrix self-interaction structure (SSIM) that shows paired relationships between sub-elements
5. Conduct FGD to obtain expert opinion and produce consensus answers between different experts into one answer. FGD.
6. Compile reachability matrix based on SSIM and check transitivity and consistency level
7. Develop the structure of the cause of ch4 gas and CH4 gas mitigation strategy. The assessment of elements and sub elements is composed in the Structural Self Interaction Matrix (SSIM) created in the form of reachability matrix (RM) tables by changing V, A, X,O to numbers 1 and 0. Classification of elements based on Structural Self Matrix. (SSM) made under the VAXO system, namely;
8. V if eij 1 and eji 0; V sub-element i plays more role than j-element and vice versa
9. A if eij 0 and eji 1; A j-element plays more of a role than the ith sub-element and vice versa
10. X if eij 1 and eji 1; X the two sub-elements have the same role level values and are interconnected
11. O if eij 0 and eji 0; O the two sub-elements are not interconnected.

4. RESULTS

4.1. Methane from Livestock Manure

In addition to enteric CH4, livestock manure is also a source of CH4, especially when stored aerobic [19].

Contribution of ruminator cattle excrement against CH4 emissions is about 2% and 0.4% for global GHG. The increase in GHG has to do with the thematic population, livestock species, livestock farming, animal feed type, sewage management, and the behavior of farmers in livestock cultivation [5].

The composition of solids in impurities affects the anaerobic decomposition of organic matter and the production of CH4. Analysis of brood cattle manure showed a value of C 48.83%,, N 1.16%, P Total 1.33% and K a total of 0.53%.

In building the CH4 gas mitigation strategy from livestock excrement continues to be carried out through the identification of FGD results, 11 main factors are the cause of CH4 gas emissions from livestock manure and there are 7 strategies for CH4 gas mitigation. The result of grouping sub-elements into elements causing CH4 gas emissions puts sub-elements in 4 groups (Figure 1). The first group is a sub-element of the quality of the farmer's, the number of livestock and the management of livestock manure has a strong boost but its low dependence on other sub-elements.The strong influence of sub-elements in the first group is a key factor (Figure 2) for CH4 gas mitigation from cattle manure.

The farmer's human resources are very decisive in the management of cattle manure that will produce CH4 gas, activities carried out by farmers such as feeding livestock, cleaning cages and livestock, and managing manure to be used as biogas and compost fertilizer.

The group of two sub-elements have a high degree of influence and the level of dependency is also relatively high to other sub-elements, namely; limited business capital, livestock breeds and limited assistance from the government in livestock cultivation. The third group has a low level of influence and high sustainability, which is the limited infrastructure that exists around the farm site. While group 4 has a low level of influence and also low dependence on other sub-elements, namely; livestock life, feed quality and livestock maintenance patterns.

ISM analysis resulted in sub-elements feeding additional concentrates and building biogas installations and the manufacture of compost fertilizer from livestock manure as a key sub element due to its high thrust and low dependence (Figure 3). The structural model of the mitigation strategy factor can be found in (Figure 4). This is very much related to the quality of feed given by farmers to cattle still in the form of airy grass and kumpai grass (Hymenachne amplixicualis).

The second priority is to build a good stable facility that has low thrust and high dependence. Then the third group consists of sub-elements utilizing biourin, the pattern of cattle integration, maintaining the health of livestock and controlling the temperature of the cage. These sub-elements have low thrust and also low dependency.

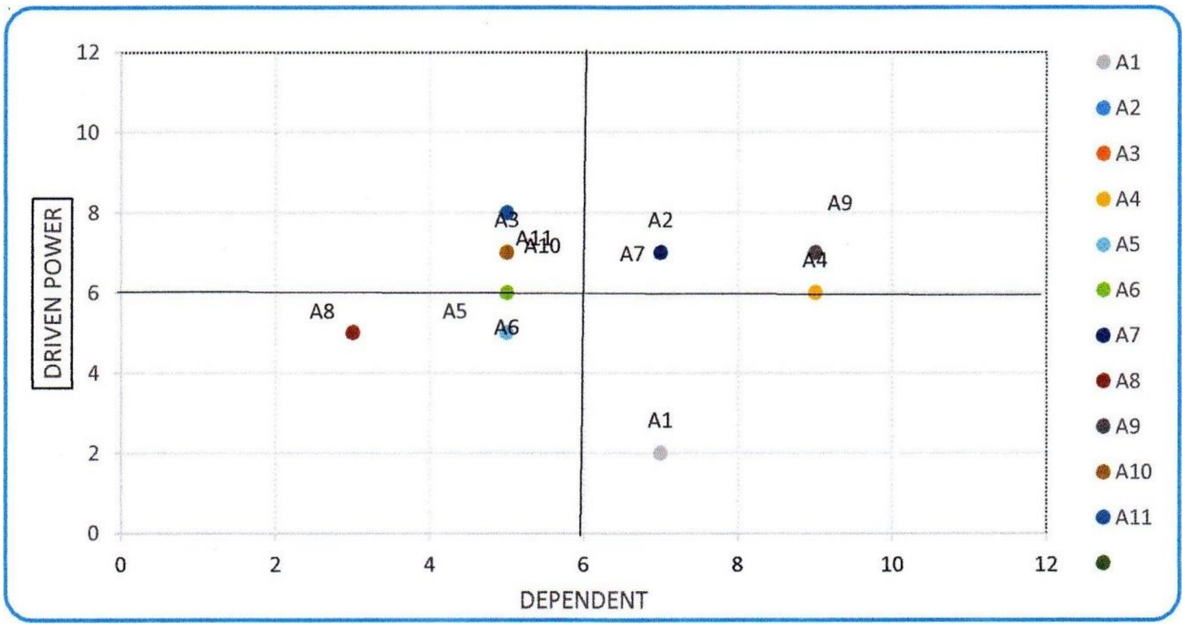

Figure 1 Sub-element grouping diagram of the causes of CH4 gas emissions

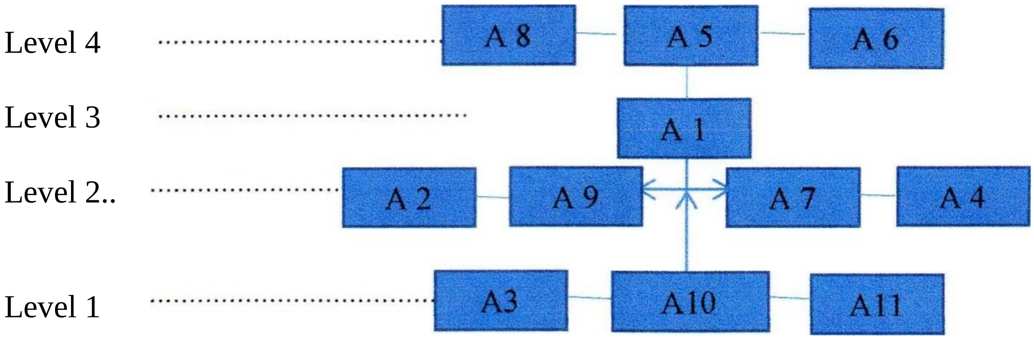

Figure 2 Structural model of key sub-elements causing CH4 gas to occur

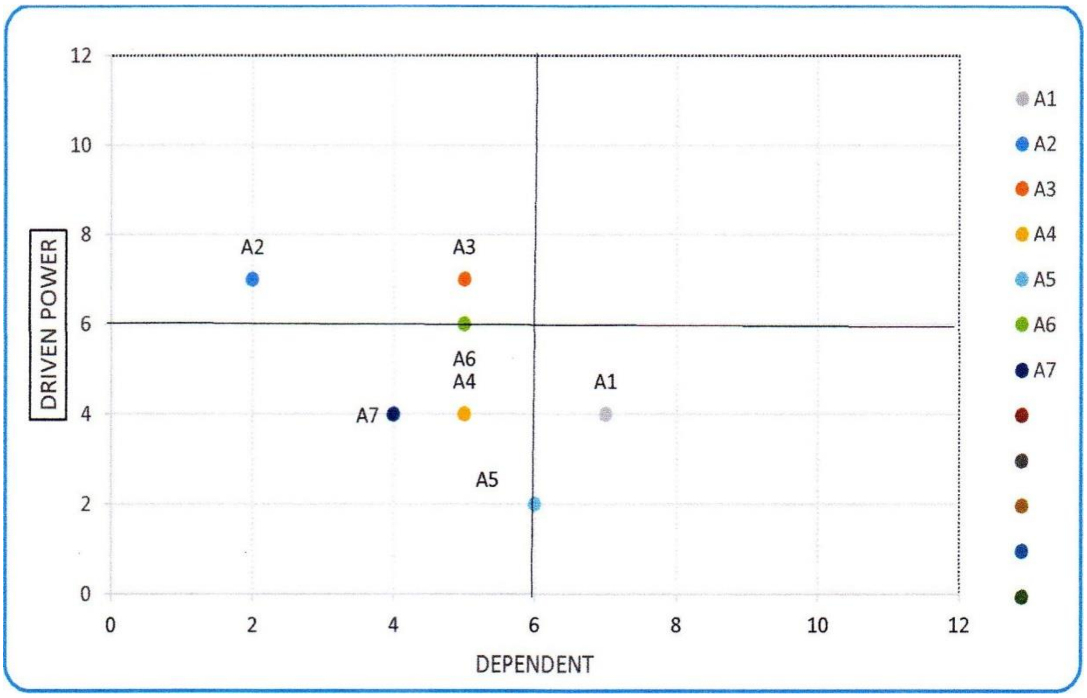

Figure 3 Sub-element grouping diagram of CH4 gas mitigation strategy of cow manure

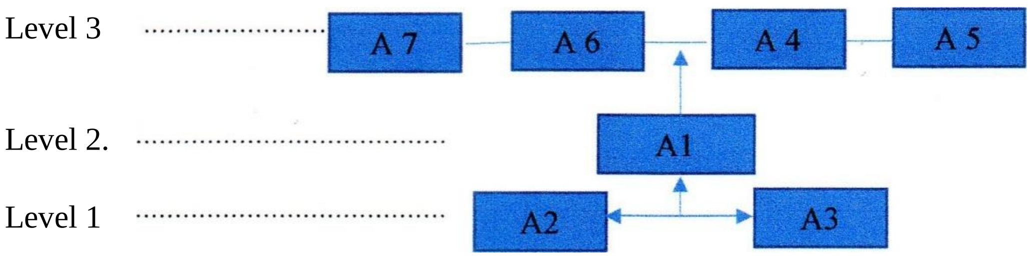

Figure 4 Key sub-element structure model strategy for CH4 gas mitigation.

5. DISCUSSION

CH4 emissions from sewage have a greater proportion of total CH4 emissions from dairy farms with sewage storage systems and lower in extensive systems [20]. Manure emissions are relatively high in areas where livestock manure from the dairy sector is managed in a liquid system that produces a larger amount of CH4 emission [21]. During sewage storage, CH4 gas will experience the same reaction as enteric fermentation. Cellulose dalarn feces degraded by microbes through methanogenesis process [22].

Livestock manure contains organic materials such as proteins, carbohydrates and fats that can be used as a source of feed and energy for the growth of anaerobic bacteria. The benefit of gas CH4 is the energy in the form of the gas itself. Gas production from sewage depends on the management system. The result of gas can be a certain amount of gas produced per unit degraded by anaerobic bacteria [23].

The amount of carbon contained in the cow's excrement is related to the high CH4 gas. This is because cattle are only fed forage in the form of kumpai grass (Hymenachne amplixicualis) with a coarse fiber content of 28.22% and coarse protein l0.ll%. According to [24] solid impurities consist of fatty acids, proteins and carbohydrates where fatty acids, proteins and parts and carbohydrates are easily decomposed.

The composition of feed or forage quality affects CH4 production in ruminant. Digestion in rumen depends on the activity of microorganisms that need energy, nitrogen, and minerals [25]; [26]. Therefore, forage quality affects the activity of rumen microbes and the production of CH4 in rumen. Forage species, forage processing, forage proportions in food, and grain sources also affect CH4 production in ruminant. Methane production tends to decrease as feed protein content increases, and will increase with increased feed fiber content [26]. CH4 production is positively associated with feed digestion and is negatively associated with the fat concentration of food, whereas the carbohydrate composition of food has only minor effects [22]. CH4 production has a negative impact on livestock productivity, resulting in energy loss ranging from 2% to 12% of GEI animals [27].

Solid impurities containing nitrogen are associated with CH4 gas diffusion/especially at ground level, but do not affect ch4 gas transformation. The integration of livestock manure with nitrogen fertilizers can not only provide optimum results, but also successfully reduce the risk of CH4 emissions [28].

According to [5] CH4 emissions from livestock waste management from 2014, 2015, 2016, 2017 and 2018 respectively 2869.38 (C02-e ton/ head); 3060.96 (C02-e ton/head); 3217.60 (C02-e ton/ head); 3350.47 (C02-e ton/ head) and 3342.95 (C02-e ton/ head).

5.1. Structure of Methane Gas Mitigation Factors

Methane is estimated to contribute about 18% of the expected total global warming in the next 50 years [29], where livestock's contribution to total/global emissions is approximately 9% [30]. Domestic animals account for about 94% of total global emissions [29]. Although emissions have been reduced per unit of animal products, total emissions have increased from very large animal populations around the world [31]. By 2050, total CH4 emissions from ruminant livestock are expected to increase significantly due to the increasing demand for milk and meat for the world's rapidly growing population [21]. Therefore, it is very important to reduce CH4 emissions from the livestock industry.

The agricultural sector accounts for 10-12% of the total antrapogenic GHG, consisting of CH4 and N20, while the livestock sector accounts for about 18-51% of the antrapogenic GHG, which consists mostly of CH4 gas [32]. The increase in GHG has to do with livestock populations, livestock breeding, farming, animal feed types, sewage management, and the behavior of livestock farmers.

Cow manure in the form of feces and urine is generally collected by farmers behind cages, and spread around grass crops. Then cow urine is generally still /many that have not been processed into biourin for plant fertilizer or for sale [5].

The current condition of farmers still needs help from the government both for the procurement of seeds, concentrate feed, and other supporting infrastructure advice. the human resources factor of farmers is still low so farmers always expect help from other parties such as from the government and investors, this is causing high dependence from farmers. Farmers perform the pattern of intensive and semi-intensive maintenance of cattle, but the needs of livestock are still not met optimally.

5.2. Methane Gas Mitigation Strategy Factor Structure

CH4 gas mitigation strategies carried out by cattle farmers have not continuously provided additional feed in the form of concentrates for cattle. This is related to the economic capabilities of farmers who are more focused on basic needs, while for other activities such as building cages and making compost fertilizer is a part-time activity.

The current conditions of farmers building cattle sheds only for shelter and have not noticed the ideal stable conditions around the settlement. This has to do with the ability of human resources of farmers who do not know much about the benefits of good livestock cages and the processing of feces and biourins of livestock, how to maintain the health of livestock, and maintain a comfortable stable temperature condition for livestock so that manure can be processed into environmentally friendly products, such as the manufacture of biogas and compost fertilizer for the mitigation of CH4 gas from cattle manure.

CH4 gas mitigation strategy requires an action to improve feed quality with the addition of concentrates that are easily printed with low coarse fiber. Then in addition to feed management, an effort is needed to build biogas installation and compost fertilizer production. The manufacture of biogas will benefit farmers as an environmentally friendly energy source because energy comes from CH4 gas. While the manufacture of compost fertilizer from the dirt will reduce ch4 gas released into the air. CH4 production from enteric fermentation is the largest contributor to GHG followed by CH4 derived from manure management system and land application [19] ; [33]; [34].

6. CONCLUSIONS

The main factors causing CH4 gas emissions are the low quality of farmers' human resources, the development of livestock numbers and the optimal management of livestock waste contributing to CH4 gas emissions. In addition, limited infrastructure in the maintenance of cattle also led to CH4 gas emissions. CH4 gas mitigation effort, in the maintenance of livestock is attempted to provide additional feed in the form of concentrates and build biogas installations and the manufacture of compost fertilizer from cattle manure.

ACKNOWLEDGMENTS

Thanks to the Rector of Jambi University, Chairman of research and community service institute, Postgraduate Director of Jambi University, who has provided research funding assistance so that this research can be carried out.

REFERENCES

[1] IPCC 1994. Greenhouse Gas Inventory Workbook: IPCC Guidelines for National Greenhouse Gas Inventories Volume 2, UNEP-WMO.

[2] Harianto, B dan A. Thalib. 2009. Emisi metan dan fermentasi enterik: kontribusinya secara nasional dan faktor-faktor yang mempengaruhi pada ternak. Balai Penelitian Ternak.

[3] Gustiar. F., R.A. Suwignyo., Suheryanto dan Munandar. 2014. Reduksi gas metan (CH4) dengan meningkatkan komposisi konsentra dalam pakan ternak. Jurnal Peternakan Sriwijaya, Vol 3, No 1, Juni 2014 pp. 14-24.

[4] Pramono, A. 2016. Potensi penurunan emisi gas rumah kaca pada pengelolaan kotoran hewan sapi melalui penambahan pakan tambahan. Balai Penelitian Lingkungan Pertanian. DOI: 10.30598/jhppk. 2016.1.2.111. ISSN Online: 2621-8798, Hal 111-116.

[5] Syarifuddin H dan A. Rahman Sy. 2019. Inventarisasi Emis Gas Rumah Kaca (CH4 dan N20) Dari Sektor Peternakan Sapi Dengan Metode Tier-l IPCC Di Kabupaten Muaro Jambi. Jurnal Ilmiah Ilmu-llmu Peternakan Vol 22. No 2 Edisi Nopember 2019. ISSN: 1410-7791. Hal 74-84.

[6] Suryahadi AR., Nugraha AB. , dan R. Boer. 2002. Laju konversi metan dan faktor emisi metan pada kerbau yang diberi ragi tape lokal yang berbeda kadarnya yang mengandung Saccharamyces cerevisiae. Ringkasan Seminar Program Pascasarjana Institut Pertanian Bogor

[7] Sohani N. dan N. Sohani, 2012. Developing Interpretive Structural Model for Quality Framework in Higher Education: Indian Context. Journal of Engineering, Science & Management Education. 5(11), pp. 495—501.

[8] Shahabadkar P., S. S. Hebbal, S. Prashant, 2012. Deployment of Interpretive Structural Modeling Methodology in Supply Chain Management — An Overview. International Journal of Industrial Engineering and Production Research. 23(3), pp. 195-2005.

[9] Azar A. dan K. Bayat, 2013. Designing a model for "Business process-orientation" using interpretive structural modeling approach (ISM). Academic Journals. 7(26), pp. 25582569

[10] Santoso, P.B.K., Widiatmaka., Sabiham, S., Machfud., dan Rusastra, I. W. 2017. Analisis Pola Konversi Lahan Sawah dan Struktur Hubungan Penyebab dan Pencegahannya (Studi Kasus Kabupaten Subang, Provinsi Jawa Barat). Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan Vol. 7 No. 2 (Agustus 2017): 184-194.

[11] Eriyatno, 2013. Ilmu Sistem, Surabaya. Guna Widya.

[12] Lin L. Z. dan H. R. Yeh, 2013. Analysis of tour values to develop enablers using an interpretive ` hierarchy-based model in Taiwan. Tourism Management. 34, pp. 133-144.

[13] Khan I. dan Rahman 7 , 2015. Brand experience anatomy in retailing: An interpretive structural modeling approach. Journal of Retailing and Consumer Services. 24: pp. 60-69.

[14] BPS, 2019. Statistik Provinsi Jambi. Pemerintah Provinsi Jambi.

[15] Janes F. R. , 1988. Interpretive structural modelling (ISM): a methodology for structuring complex issues. Trans Inst MC. 10(3). Available at http://sorach.com/items/ismjanes. pdf (Accessed August 21, 2014)

[16] Kannan G. , S. Pokharel, P. S. Kumar, 2009. A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider. Resources, Conservation and Recycling. 54, pp. 28-36.

[17] Govindan K. , D. Kannan, A. N. Haq, 2010. Analyzing supplier development criteria for an automobile industry. Industrial Management & Data Systems. 110(1): pp. 43—62.

[18] Jadhav J. R. , S. S. Mantha, S. B. Rane, 2015. Analysis of interactions among the barriers to JIT production: interpretive structural modelling approach J Ind Eng Int. 1 1: pp. 331—352.

[19] Klevenhusen, F. — Kreuzer, M. — Soliva, C. R. Enteric and manure-derived methane and nitrogen emissions as well as metabolic energy losses in cows fed balanced diets based on maize, barley or grass hay. Animal, vol. 5, 2011, p. 450-461. 2011.

[20] Knapp, J. R. -Laur, G. L. - Vadas, P. A. - Weiss, W. P. - Tricarico, J. M. Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal ofDairy Science, vol. 97, 2014, p. 3231—3261. 2014.

[21] Gerber, P.J, Steinfeld H. , Henderson B. , Mottet A. , Opio C. , Dijkman J. , Falcucci A., Tempio G. 2013. Tackling climate change through livestock a global assessment of emissions and mitigation opportunities. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO); 2013.

[22] Chianese, D.S., Rotz, C.A. and Richard, T.L. (2009a) Whole Farm Greenhouse Gas Emissions: A Review with Appli- cation to a Pennsylvania Dairy Farm. Applied Engineering in Agriculture, 25, 431-442. http://dx.doi.org/10.13031/2013.26895

[23] Song, M.K., Li, X.Z., Oh, Y.K., Lee, CK. and Hyun, Y. 2011. Control of Methane Emission in Ruminants and Indus- trial Application of Biogas from Livestock Manure in Korea. Asian-Australian Journal of Animal Science, 24, 130-136. http://dx.doi.org/10.5713/ajas.2011.r.02

[24] Godbout, S. , Verma, M. , Larouche, J.P., Potvin, L. , Chapman, A.M., Lemay, S P., Pelletier, F. and Brar, SK. (2010) Methane Production Potential (BO) of Swine and Cattle Manures—A Canadian Perspective. Environmental Technolo- gy, 31, 1371-1379. http://dx.d0i.org/10.1080/09593331003743096.

[25] Moss AR, Jouany J.P., Newbold, C.J. 2000. Methane production by ruminants: its contribution to global warming. Ann Zootechnol. 49:231-235..

[26] Shibata, M. and Terada, T. (2010) Factors Affecting Methane Production and Mitigation in Ruminants. Animal Science Journal, 81, 2-10. http://dx.doi.org/10.1111/ j.1740. 0929 .2009.00687.x.

[27] Ramin, M. and Huhtanen, P. 2013. Development of Equations for Predicting Methane Emissions from Ruminants. Journal of Dairy Science, 96, 2476-2493. http://dx.doi.org/10.3168/jds.2012-6095

[28] Nan, W. , Li, S. , Dong, Z. , and P Yao. 2020. 'CH4 fluxes and diffusion within soil profiles subjected to different fertilizer regimes on China's Loess Plateau', Agriculture, Ecosystems and Environment. Elsevier, 287(September 2019), p. 106679. doi: 10.1016/j.agee.2019.106679.

[29] Milich L. 1999. The role of methane in global warming: where might mitigation strategies be focused? Glob Environ Chang. 179-201.

[30] IPCC, Climate change 2007. In: Mertz B, Davidson OR, Bosch PR, et al., editors. Mitigation. Contribution of working group iii to the fourth assessment report of the intergovernmental panel on climate change. United Kingdom and New York, NY, USA: Cambridge University Press, Cambridge; 2007

[31] Opio C, Gerber P, Mottet A, Falcucci A, Tempio G, MacLeod M, Vellinga T, Henderson B, Steinfeld H. 2013. Greenhouse gas emissions from ruminant supply chains — a global life cycle assessment.

Rome, Italy: Food and Agriculture Organization of the United Nations (FAO); 2013

[32] Goodland, R. , Anhang, J. Livestock and Climate Change: What If The Key Actor In Climate Change are Cows, Pigs, and Chickens? Word Watch Institute pp 10-19. 2009.

[33] Hristov, A. N.Ott, T. Tricarico, J.— Rotz, A. — Waghorn, G. — Adesogan, A.—Dijkstra, J. — Montes, F. — Oh, J. — Kebreab, E. — Oosting, S. J. — Gerber, P. J. —Henderson, B. — Makkar, H. P. S. — Firkins, J. L. Mitigation of methane and nitrous oxide emissions from ammal operations: Ill. A review of animal management mitigation options. Journal ofAnimal Science, vol. 91, 2013, p. 5095—5113. 2013

[34] Montes, F. - Meinen, R. - Dell, C. - Rotz, A.- Hristov, A. N. - Oh, J. - Waghorn, G. - Gerber, P. J. — Henderson, B. — Makkar, H. P. S. — Dijkstra, J. Mitigation of methane and nitrous oxide emissions from ammal operations:A review of manure management mitigation options. Journal ofAnimal Science, vol. 91, 2013, p. 5070—5094. 2013.