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Bayesian Network approach in analyzing the sustainability of the cultural industry 'the sacred' Gringsing Weaving

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Bali is a popular tourist destination in the world, and the main entry point for foreign tourists to Indonesia. Bali is also an area in Indonesia that is famous for producing woven fabrics, which have various characteristics in each region. Gringsing weaving is one of the traditional Balinese fabrics from Tenganan Village which is considered sacred and its manufacture takes quite a long time, and is carried out with special techniques that are very difficult. This study aims to analyze and map factors related to the sustainability of the Gringsing weaving cultural industry, using the Bayesian Network approach. The results of the FGD with related stakeholders mapped the structure that forms Gringsing industrial sustainability, such as income, social capital, incentives, natural capital, custom law, and traditional institutions. Further analysis was carried out using the Bayesian Network technique and GeNIe tools. In forming the structure of thinking about the sustainability of the Gringsing Weaving industry, the related factors include culture, traditional institutions, natural capital, social capital, to economic factors, such as income and special incentives from the government. Specifically, the role of traditional institutions and government (through special incentives) was analyzed, and it was found that both factors can increase the probability of the sustainability of the gringsing weaving industry. The results of the sensitivity analysis also show that the sustainability of the Gringsing weaving industry is highly influenced (sensitive) to the increasing role of traditional institutions.

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1. Introduction

Bali is a popular tourist destination in the world (Hendrajana, 2022; Rustini et al., 2023), and the main entry point for foreign tourists visiting Indonesia (Endartyana, 2017). Bali is also called the islands of God because of the many temples in Bali. In addition, the Balinese people are known as a religious society, who carry out various Hindu-themed religious rituals in their daily lives (Paramita et al., 2011; Widana & Julianingsih, 2023). The Balinese people are also known to have creativity combined with art and culture (Pratiwi et al., 2017). Its real manifestation is in various forms of art and art products that are full of meaning. Some products that are typical of Bali include wood crafts, silver crafts, including woven fabrics (Davies, 2007; Kamal et al., 2020; Pringle, 2004). Bali is an area in Indonesia that is famous for producing woven fabrics, which have various characteristics in each region. In general, there are six types of Balinese woven fabrics, namely songket fabric, cepuk fabric, gringsing fabric, kling fabric, poleng fabric, and endek fabric (Rahayu, 2024). Traditional Cultural Expressions (TCEs), including one of which is "Traditional Balinese Weaving" is an intellectual property documented from philosophy, function, history, custodian, culture, to current conditions (Dharmawan, 2017).

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Specifically, for gringsing woven cloth, it is a traditional woven product that can only be found in Tenganan Pegeringsingan Village as an "original Balinese" village (Sukawati, 2020). Gringsing is considered sacred and is believed to be able to ward off evil magical powers or 'black magic'. Gringsing comes from the word "gering" which means sick and "sing" which means no. So that gringsing cloth is woven by the Bali Aga people, one of which is intended to ward off disease. Its manufacture takes quite a long time, starting from one to five years and is carried out with a special technique that is very difficult. The finished result of this weaving will create a neat geometric pattern that is harmonious and very beautiful (Utami, 2014). Weaving activities are carried out at home in their spare time by women, but the tools used are made by men. In making this woven cloth, there are special regulations that determine when is a good time to start weaving. The determination of a good day already has rules in the Tenganan Pagringsingan community. Good days in the Tenganan community are called ngebeteng days which come every three days. In making gringsing weaving, the Tenganan community has a rule or prohibition that must be obeyed when making weaving. First, weaving must be done on good days because not all days can be used for weaving. A day that is considered good is a day that does not coincide with the moon. Weaving on good days has been calculated in the Tenganan Pagringsingan community. The good day to start weaving is calculated not using conventional days, but using days or calendars that have been determined by the Tenganan Pagringsingan community. Second, weaving must not coincide with traditional ceremonies of the Tenganan Pagringsingan community (Sukawati, 2020). Its potential to increase legal awareness at the artisan community level with the support of the Regional Government through the Cooperatives and UMKM Service. This support will help preserve the local wisdom of Endek and Songket Ikat products, which have local, national, regional, and international market shares (Asrini et al., 2024). Even Gringsing woven cloth became a souvenir of the G20 meeting and was proposed as a world cultural heritage.

Fig. 1. Weaving Techniques and Use of Gringsing
Source: Ministry of Tourism and Creative Economy (https://www.kemenparekraf.go.id/)

Gringsing woven fabric is produced by the Bali Aga Tenganan Pagringsingan community, Karangasem. However, the dyeing process is carried out in other areas, such as Nusa Penida and Bugbug. The dyeing process uses natural materials, but it cannot be done in Tenganan Village. Tenganan Traditional Village has a local law that it is not allowed to pollute the Tenganan Village area, so the dyeing process cannot be carried out in Tenganan Village. This does have a positive impact on the environment of Tenganan Village, but on the other hand it also threatens the sustainability of the industry, because the supply of raw materials (yarn dyeing) is influenced by the availability of dyeing in other areas. The Tenganan Traditional Village community is aware of the risk of environmental pollution in the dyeing location area. So the willingness to pay (WTP) for the risk of pollution is important. The use of environmentally friendly products can increase the willingness to pay consumers with high environmental concerns (Notaro & Paletto, 2021). Sustainable consumption and the use of environmentally friendly raw materials can support an increase in WTP (White et al., 2019). The commodification of Gringsing woven fabric is inevitable, and is indeed economically potential. Although the price is expensive due to the complicated process and long manufacturing process, there are quite a lot of people interested in this fabric, especially the upper middle class. Stalls opened by women in the informal sector do provide added economic value but are not significant due to the lack of ability to manage stalls (Taua'a, 2018). The purpose of this study is to analyze and map factors related to the sustainability of the Gringsing woven cultural industry, using the Bayesian Network approach. In addition to describing the relationship between factors in existing conditions, the Bayesian network approach also presents probabilities in several scenarios by optimizing certain factors. This can certainly be used as a basis for formulating a very urgent strategy to be carried out.

2. Material and method

2.1 Theoretical framework

UNESCO (UNESCO, 2018) stated that "no development can be sustainable without including culture". So that the rapid industrial development accompanied by cultural elements, gave birth to the terminology "culture industry" (Tejawati, 2020). This terminology is considered more appropriate when compared to the terminology of mass culture (Adorno, 1991; Sanders, 2010). Some researchers emphasize the cultural and symbolic value of the output of the cultural industry. While other

researchers emphasize the output on the intangible nature and protection of intellectual property (WIPO, 2023). In economic terms, the "cultural sector" includes the industrial and non-industrial sectors (Emilia et al., 2008). The cultural economy includes the cultural sector and the creative sector. The contribution of culture to the economy is gradually recognized, along with the development of the cultural industry (Ngo et al., 2019). Local institutions (including community participation in them) are things that need to be considered in sustainable development (Uphoff, 1992). Local institutions and organizations have been widely recognized and taken into account in development policies in many countries (Fisher, 2004). After all, people at the community level know each other better and can create opportunities for collective action and mutual assistance and manage resources independently (Febryanto et al., 2014). Furthermore, community-based rural industry management can transform unsustainable practices into more sustainable ones through a number of ways, such as self-organization, institutional development, experimentation, knowledge development, and social learning (Marschke & Berkes, 2005). In relation to the gringsing woven cloth cultural industry in Tenganan Traditional Village, it is known that the Tri Hita Karana philosophy is the basic concept for building harmony. Tri Hita Karana consists of the word "tri" which means three, "hita" which means happiness/harmony, and “karana” which means “cause”, so that tri hita karana can be interpreted as three causes of happiness/harmony. Tri Hita Karana consists of the elements of parahyangan, pawongan, and palemahan or a harmonious relationship between humans and God, with fellow humans, and with nature. This harmony is seen in the preparation of raw materials and the entire process in making gringsing woven cloth (Lodra, 2015).

2.2 Bayesian Network approach

Bayesian Belief Network (BBN) or Bayesian Networks (BN) is a causal probabilistic network used to measure the sustainability of the gringsing weaving cultural industry. Modeling with BN tends to be easier to understand because it can describe the network clearly. In addition, model development and variable addition can be done dynamically when the system is built, and allows for the correction of incomplete data samples by adding or integrating probabilities with possible values of the variables (Kisioglu & Topcu, 2011).

Bayesian Network can be used for building models from data and expert opinions, and it consists of: (1) Directed Acyclic Graph (DAG), and (2) Table of conditional probabilities. The generalized form of Bayesian network that represents and solves decision problems under uncertain knowledge is known as an Influence diagram. A Bayesian network graph is made up of nodes and Arcs (directed links), as shown as Fig. 2.

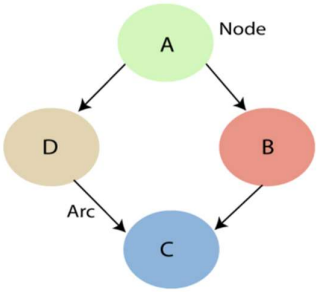

Fig. 2. Simple Bayesian Network Graph

Each node corresponds to the random variables, and a variable can be continuous or discrete. Arc or directed arrows represent the causal relationship or conditional probabilities between random variables. These directed links or arrows connect the pair of nodes in the graph. These links represent that one node directly influences the other node, and if there is no direct link that means that nodes are independent with each other. In Fig. 2., A, B, C, and D are random variables represented by the nodes of the network graph. If we are considering node B, which is connected with node A by a directed arrow, then node A is called the parent of Node B, and Node C is independent of node A.

The Bayesian network has mainly two components, i.e. causal components and actual numbers. Each node in the Bayesian network has condition probability distribution $P(X_i | Parent(X_i))$, which determines the effect of the parent on that node. The Bayesian network is based on Joint probability distribution and conditional probability. If we have variables x1, x2, x3, ..., xn, then the probabilities of a different combination of x1, x2, ..., xn, are known as Joint probability distribution.

P[x1, x2, x3,....., xn], it can be written as the following way in terms of the joint probability distribution.

= P[x1| x2, x3,....., xn]P[x2, x3,....., xn]

= P[x1| x2, x3,....., xn]P[x2|x3,....., xn]....P[xn-1|xn]P[xn].

In general, for each variable Xi, we can write the equation as:

P(Xi|Xi-1,....., X1) = P(Xi |Parents(Xi)).

2.3 Identifying variables

BN modeling procedure begins by identifying variables as the basis for forming network structure and probability rule (Hoshino et al., 2016). The variables identified in this study are categorized as in Table 1.

Table 1
Variables of BN Analysis of Gringsing Industrial Sustainability

Variable Category	Description	Variable Nodes (Nodes States)	Nodes States
Objectives	The things that wish to affect through the system.	Industrial sustainability	Yes, No
Interventions	The things that wish to implement in order to achieve the objectives.	Income Social capital Special incentives	High, Medium, Low High, Medium, Low Yes, No
Intermediate factors	Factors which link objectives and interventions.	WTP Culture	Willing, Not willing Preserved, Unpreserved
Controlling factors	Factors which cannot be changed by intervening at the scale that are considering but control.	History Natural capital *Awig-awig* (custom law)	Understand, Don't understand Limited, Unlimited Strict, Less strict
Implementation factors	Factors which directly affect whether the intervention can be successfully implemented both immediately and in the future.	Special stall potential Traditional institutions Intellectual Property Right (IPR)	Yes, No High role, Low role Yes, No

2.4 BN Structure

Based on the identified variables (Table 1), these variables can be constructed in a DAG BN structure as shown in Fig. 3.

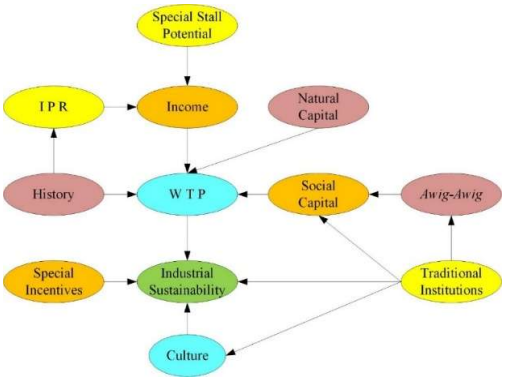

Fig. 3. Simple Bayesian Network Graph

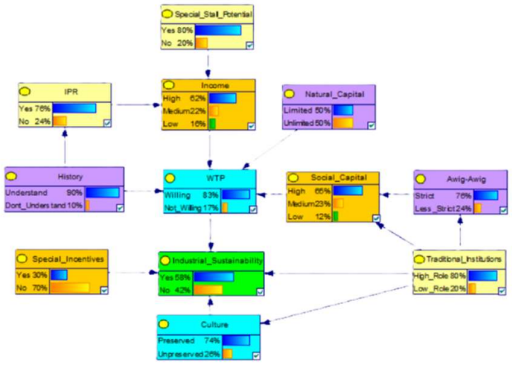

Fig. 4. BN Structure of Gringsing Industrial Sustainability with Prior Probabilities

After the DAG BN structure is compiled, stakeholders then agree on the probability of each node. The results are compiled in a Conditional Probabilistic Table (CPT) and analyzed using the GeNIe Academic 4 Version tool.

3. Results and Discussion

3.1 Strength analysis

The output DAG BN Structure corresponds to the analyzed CPT, as shown as Fig. 4. To clearly understand the strength or influence between nodes, namely between parent and child nodes, the output also presents a score of strength as shown in Table 2. Table 2 shows that the highest score is on the influence of history on Intellectual Property Rights (IPR), namely with an average score and maximum score of 0.4. As we all know that in proposing or determining IPR for a product, especially a product with geographical indication, it requires an assessment of historical elements. In addition, another influence that is also high is the influence of traditional institutions on culture, with a score of 0.3. The traditional institutions in question are traditional villages, where traditional villages are institutions that regulate so that the community preserves culture. This is followed by the influence of culture on the industrial sustainability of Gringsing with a score of 0.287. As previously discussed, the activity of weaving Gringsing cloth uses raw materials and a manufacturing process that has special rules, and is carried out from generation to generation, so that a piece of Gringsing cloth produced has sacred value.

Table 2
Score of Strength Between Parent and Child Nodes of Gringsing Industrial Sustainability

Parent	Child	Average	Maximum
Awig-awig	Social Capital	0.15	0.15
Culture	Industrial Sustainability	0.287	0.287
History	IPR	0.4	0.4
History	WTP	0.016	0.016
Income	WTP	0.05	0.05
IPR	Income	0.136	0.136
Natural Capital	WTP	0.05	0.05
Social Capital	WTP	0.133	0.133
Special Incentives	Industrial Sustainability	0.137	0.137
Special Stall Potential	Income	0.15	0.15
Traditional Institutions	Awig-awig	0.2	0.2
Traditional Institutions	Social Capital	0.136	0.136
Traditional Institutions	Culture	0.3	0.3
Traditional Institutions	Industrial Sustainability	0.212	0.212
WTP	Industrial Sustainability	0.137	0.137

3.2 Optimizing the Role of Government and Traditional Institutions on Gringsing Industrial Sustainability

The sustainability of the Gringsing weaving culture industry has historical and cultural values that need to be preserved. There are also quite a lot of enthusiasts or consumers of Gringsing cloth, especially the upper middle class, considering the price is quite expensive. So it is necessary for institutional roles in the sustainability of this industry. The institutions referred to are not only traditional institutions, but also the government. The role of the government in the DAG that is being prepared is to provide special incentives for weavers who are willing to continue this industry. The optimization analysis of traditional institutions produces a probability of Gringsing industrial sustainability presented in Fig. 5.

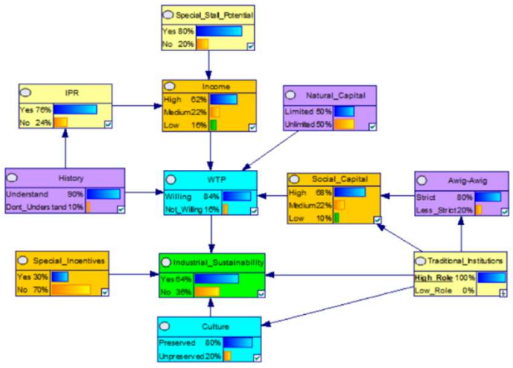

Fig. 5. BN Structure of Gringsing Industrial Sustainability with Optimal Traditional Institutions

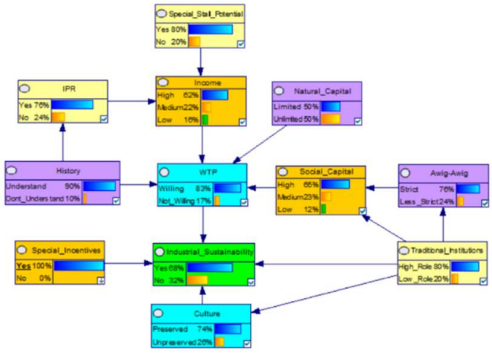

Fig. 6. BN Structure of Gringsing Industrial Sustainability with Optimal Government Role (Incentives)

Meanwhile, if the role of the government (through special incentives) is optimized, it will produce the probability of Gringsing industrial sustainability as in Fig. 6. Fig. 4 and Fig. 5 show that there is an increase in the probability of industrial sustainability of Gringsing. In the current condition (Fig. 3), the probability of the sustainability of the gringsing weaving cultural industry is 58%. Meanwhile, if the traditional institution is in optimal condition (Fig. 4), the probability increases to 64%. Even if the role of the government is optimized by providing incentives, the probability of the sustainability of the gringsing weaving cultural industry increases to 68%. This shows the important role of institutions, both traditional and government. Specifically related to incentives, benchmarking from other countries also shows the importance of incentives in the weaving industry. The sustainability of the weaving industry in the Philippines is influenced by the incentives provided (Abola et al., 2020). The existence of incentives has an impact on the cross-generational sustainability of traditional Indian weaving businesses.

3.3 Sensitivity analysis

BN analysis with GeNIe can also produce sensitivity analysis on target variables. The target in this study is the sustainability of the Gringsing weaving culture industry (Fig. 7). Fig. 7 shows a tornado diagram that illustrates sensitivity analysis, namely changes in the target, where green represents positive changes and red represents negative changes, while the length of the bar indicates the intensity/impact on the target. Fig. 7 further emphasizes the important role of traditional institutions, because the higher their role will have a great impact on increasing the sustainability of the Gringsing weaving cultural industry. While cultural preservation is considered to have a negative effect. As previously discussed, in the process of making Gringsing weaving, there are rules as a culture that must be carried out, so that the process of making Gringsing weaving is relatively

long. So it is considered that by carrying out this cultural process, the number of weaving and the number of weavers can be reduced. However, it should be realized that Gringsing weaving cannot be used as a mass product because of its sacred value.

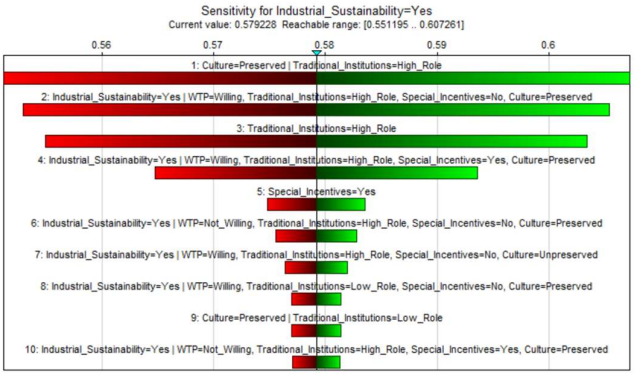

Fig. 7. Tornado Diagram for Sensitivity Analysis of Gringsing Industrial Sustainability

4. Conclusions

The sustainability of the Gringsing woven cultural industry is urgent considering that gringsing cloth is a cultural heritage with sacred value. In addition to this value, Gringsing cloth also has high economic value. Considering that this cloth is not a mass product, and in the manufacturing process it has complicated rules and processes, the number of weavers and products produced cannot be targeted and are limited.

In the formation of the structure of thinking of the Gringsing Weaving sustainability industry, related factors include culture, traditional institutions, natural capital, social capital, to economic factors, such as income and special incentives from the government. Specifically, the role of traditional institutions and government (through special incentives) was analyzed, and it was found that both factors can increase the probability of the sustainability of the gringsing weaving industry. The results of the sensitivity analysis also show that the sustainability of the Gringsing weaving industry is highly influenced (sensitive) to the increasing role of traditional institutions.

So far, traditional institutions have made efforts to preserve local customs. Meanwhile, the government has not provided special incentives. So, this can be used as a consideration for the government to consider providing incentives. The commodification of Gringsing weaving cannot be done to the extreme, or make it a mass product. Given that there is a sacred value in Gringsing weaving, one of which is due to the raw materials and the complicated manufacturing process. This needs to be a concern for the Government and traditional institutions in formulating programs to improve the welfare of weavers for the sustainability of the gringsing weaving cultural industry.

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