CHAPTER 2

Literature Review

2.1 iSIKHNAS Database

iSIKHNAS is Indonesia's integrated real-time information system for collecting, managing, reporting and using data to support animal health and production, animal movement is one of the among the data are managed by iSIKHNAS. Animal health certificate to movement (SKKH) is required for livestock movements, including: cattle, buffalo, sheep, goats, pigs and poultry that move between different districts, SKKH is issued by district livestock services officer and to issue an SKKH, the animals to be moved must be examined by a district livestock services field staff member, or the issuing officer must be familiar with the current health status of the animals, an SKKH certifies that

The animals at the time of examination are not showing any signs of infectious disease and are suitable for movement between district using iSIKHNAS.

SKKH must have an iSIKHNAS movement permit number, this number issued by submitting an SMS (SK code) to iSIKHNAS systems, with the required details; the iSIKHNAS system returns the permit number and emails a copy of the SKKH to the district office. The emailed copy can be printed, stamped, signed and given to the owner, or a manually written copy can be prepared, and the permit number written onto the SKKH (when there is no access to email). If the owner's hand phone number has been provided the farmer will receive an SMS with the Movement Permit ID. He can use this at checkpoints even if he doesn't have the original certificate. (Wiki.isikhnas., 2016)

Table 2.1. The example of animal movement from iSIKHNAS database.

ID of Skkh	SKKH creator	Date	Species	Quantity of livestock	Origin (Province, Districts, Subdistric, Village)	Destination (Province, Districts, Subdistric, Village)
12377	Nunu andika	05/09/2014	Cattle	100	Jawa Barat, Bandung Barat, Lembang, Kayuambon	Riau, Indragiri Hulu, Peranap,Semelinang Tebing
75838	Yeni Sri Rahmani	29/05/2015	Cattle	6	Jawa Barat, Tasikmalaya, Manonjaya	Jawa Barat, Bogor, Cibungbulang,Situ Udik
2337	Nunu Andika	25/12/2013	Cattle	6	Jawa Barat, Tasikmalaya, Manonjaya	Jawa Barat, Bandung Cimeunyan
2527	Nunu Andika	01/01/2014	Broiler	2000	Jawa Barat, Garut, Cisewu, Sukajaya	Banten,Kota Tangerang

2.2 Social Network Analysis

Social network (SN) is a term emerging from the social sciences that generically refers to a group of elements and the nature and extent of the connections, relationships, or interactions between and among them. The main goal of SN is detecting and interpreting individuals within a group (Martin-Lopez et al., 2009). A network is a collection of unit of interest that may or may not be connected, the unit of interest are normally called nodes or vertices in physic or mathematics nodes could be as an individual (persons, animal, protein, genes) or collective (group of individuals such as farm, market, regions), the node may have attributes, such as type of species, geographical locations and size in term of number animal (Dubé et al., 2011).

The nodes are linked to each other to the relationship, for example, animal movement from farm A to farm B, a letter from the sender to receiver, when this link is directed is called arc, whereas an undirected or reciprocal is called edge, for example a conversation, sharing common space (market) and sharing equipment (Wasserman and Faust., 1994).

2.3 Network Data Collection

There are several methods to gather data of the network, including: infection tracing, complete contact tracing and diary based study. Infection tracing providing transmission network, starting with infected node and follow up all infected node and sampling stop when last uninfected node identified, complete tracing capture all potential infected node from the source of infected node (index case), therefore this methods is time consuming, diary based study gathered data from record contact that has occurred, a form of diary based study in livestock movement can be gathered from livestock identification and traceability system, this system recorded all daily movement of livestock and in some countries, cattle had ear tag identification number, this record provided data for analysis in static, by considering all the movements within a fixed period or dynamic network, explored through the time series analysis and look for trends in the properties, as a result, the availability of this data can be used to investigate pattern of livestock infection (Keeling and Eames., 2005). In this study, we collect data by diary based study and obtained static network in each month and compiled within a 12 months period.

2.4 Centrality

Centrality are to identify which nodes are more central or measure of a node position in the network, centrality is one of the most studies concepts in network analysis, numerous measures have been developed, including degree centrality and betweenness. (Wasserman and Faust, 1994).

2.4.1 Degree

The degree of node is the number links that districts has, for directed network the in- degree is the number of incoming links whereas the out-degree is the number of outgoing links. The degree obtained by counting number of links contact with it (Wasserman and Faust, 1994).

2.4.2 Betweenness

Betweenness is the frequency of districts in the shortest path between pairs of network districts. Betweenness of districts is calculated as the number of shortest paths of the network that pass-through node divided by the number of shortest paths of the entire network (Wasserman and Faust., 1994).

2.5 Contact Chain

The contact chain is defined as the number of district connected either directly (one step) or indirectly (more than 1 step) through other district when following the direction of the links (Nöremark et al., 2011). Ingoing contact chain measures contacts through movements onto a district. Outgoing contact chain measures the number of districts in contact with each district through movements of animals leaving the district. Ingoing and outgoing contact chain compute the sequence of movements that occur (Dubé et al., 2011).

2.6 Moran's I

Moran's *I* coefficient of autocorrelation gives an estimates degree of spatial similarity observed among neighboring values of attribute in area study, Moran's I require a weights matrix that defines a local neighborhood around each geographic unit, neighbors can be characterized through point locations (distance based) or adjacency (contiguity based) (Morans.,1950). Method of adjacency include nclude rook contiguity (polygons are adjacent if they share a border), queen contiguity (polygons are adjacentif they share a corner), and higher order contiguities (spatial lags) such as first-order (neighbours) or second-order adjacency (neighbours-of-neighbours). Moran's I formula is :

$$I = \frac{n\sum_i \sum_j W_{ij}(Z_i - \overline{Z})(Z_j - \overline{Z})}{(\sum_i \sum_j W_{ij})\sum_k (Z_k - \overline{Z})^2}$$

Where n is equal of total number of the number of spatial unit, W*ij* is measure closeness between *i* and *j*, Z is variable of interest, $\overline{Z}$ is the mean of Z. The expected value of I under the null hypothesis of no autocorrelation is not equal to zero but given by I_0= -1/ (n - 1), if the observed value of I is significantly higher than expected value, then values of Z are positively auto correlated (clustering similar attribute value) value, whereas I is lower than expected value indicates negatives (neighbors have dissimilar attribute value).

2.7 Network Centralization

Network centralization index provides an estimate of the deviation of the largest values of centrality computed in the network from the value computed for all other nodes (Freeman, 1979). Centralization of network including in-degree, out-degree and betweenness. This indicator calculates from the sum of difference between largest node centralization index (degree centralization or betweenness centralization) and the observed values divided by number of node.

2.8 Geodesic

A shortest path between two nodes is referred to as a geodesic. The diameter of a connected graph is the length of the largest geodesic between any pair of nodes, the diameter of a graph is important because it quantifies how far apart the farthest two nodes in the graph (Wasserman and Faust., 1994).

2.9 Cut points and Bridges

A cut point is a node whose removal from the graph increases the number of components and makes some points unreachable from some others. It disconnects the graph. A bridge is a link whose removal from a graph increases the number of components (disconnects the graph). The concepts of cut-point and bridge have important applications in disease control. For example, eliminating cut-points and bridges from a SNA of animal movements may facilitate the application of policies and strategies to manage risk and to prevent or control disease spread (Dubé et al., 2011).

2.10 Size

The size of a network is the total number of nodes and contacts that compound the network (Dubé et al., 2011).

2.11 Density

Sum of the number of all links divided by the number of possible links in the network. The density of a digraph is a fraction that goes from a minimum of 0, if no links are present, to a maximum of 1, if all links are present (Wasserman and Faust., 1994).

2.12 Components

The node in a disconnected graph may be partitioned into two or more subsets in which there are no paths between the nodes in different subsets. The connected subgraphs in a graph are called components. Strong component are regions of the network where every node can be reached from every other node respecting the direction of the link, whereas weak component are areas of the network in which nodes are linked but we ignore the direction of the link (Robinson et al., 2007). Kao et al. (2006) proposed that the size of the largest strong component is an estimate of the lower bound on the maximum of epidemic size, while the size of the largest weak component is an estimate of its upper bound.

2.13 Cluster Coefficient

The cluster coefficient gives the average probability of individual nodes being directly connected, i.e. nearest neighbour, to another node in the network (Watts and Strogatz., 1998). Clustering coefficient is the sum of the proportions of nodes that are directly connected to another node. The possible maximum value of 1 indicates that every node is directly connected to all other nodes in the network, i.e. each node is the nearest neighbour of all other nodes.

2.14 Type of Networks

Topology networks is study of structure of the elements (node and link) network, based on structure of link there are various type of type of networks have been defined and used as models to study the structural composition of social networks, including: random, lattice, small world and scale free.

2.14.1 Random Networks

In random network, all individual has the same low probability contact with each other, generated by laying down a node and adding edges between them with independent probability for each node pair. The random network in which all connections are assigned randomly, based on the poisson or normal distribution. Random networks are characterized by short path lengths, because connections within them are established randomly, to any part in the network, with the same probability and low clustering (Watts and Strogatz., 1998).

2.14.2 Lattice Networks

Lattice networks tend to have longer paths and higher clustering coefficients than random networks of similar size, because some regions of the network are topologically remote from others (Shirley and Rushton., 2005).

2.14.3 Small World Network

Network as small-world it should have: similar average path length with random network but greater clustering than an equivalent random network, this network tends to have short paths but high clustering coefficient, i.e. most nodes are not directly connected to each other, but can be reached through a small number of steps. The shorter the average path length, or the more connections among nodes in the network, the faster an epidemic can spread. Disease spread more easily in small world compare to random or lattices and the presence of the few long-range connections provide shortcuts across the network and allowing a spreading infection through new susceptible areas (Newman., 2003). Within a smallworld network, disease spread can be successfully constrained by targeting the links that connect clusters (Watts and Strogatz., 1998).

2.14.4 Scale Free Network

In scale-free networks the degree distributions fit a power law distribution (Albert et al., 1999). This distribution is characterized by the absence of a peak and the presence of a long tail which gives it a high variance in some nodes act as "highly connected hubs" (high degree). Epidemics can spread faster on scale-free networks because of the existence of hubs as compared with random networks of equivalent size (Kiss et al., 2006). However, once the hubs are infected and have infected their partners, infection then spreads more slowly than on random networks (Kiss et al., 2006), which can lead to smaller epidemic sizes (Kao et al., 2006). Therefore, disease control strategies that target the most highly connected nodes (or hubs) in a scale-free network will be more effective than those used on randomly selected nodes (Kiss et al., 2006). In fact, the resilience, or resistance to fragmentation of scale-free networks to random removal of nodes is a major characteristic of these networks, most nodes in a scale-free network have low degree values so that any randomly selected node is unlikely to be a hub and its removal by disease control procedures will do little to interfere with the structure of the network and the spread of disease on that network (Albert et al., 2000).