

# GIS Based Spatial Analysis and Hotspot Detection of Kidney Disease

[ Wilgamuwa Division, (Matale)]

Panamaldeniya Mudiyansele Chathurika Senanayake

University of Sri Jayewardenepura, Sri Lanka

**Abstract-** The aim of this Study is to design and implement Geographic Information System (GIS) based spatial analysis and hotspot detection of Kidney disease of Wilgamuwa Division, Matale District. The Development of this model is motivated to provide opportunity for healthcare practitioner to gain access to information that can aid him/her to locate the areas of patients and to take necessary measures and to implement awareness programs to reduce the number of kidney disease patients. Although considerable research has been for health GIS applications, two challenges still need to be addressed, this relate to health mapping methods and lack of accessibility to an organized data model. To handle this problem we design a Database GIS for hospital staff to support data sharing and representation. The developed model makes it possible for healthcare practitioner to locate the patients. The study explores the use of open source software, ARCGIS 10.1. The analyzed data and the hotspot analysis will pave the way to the medical practitioners to locate the high risk and low risk areas and to identify the relationship of the distribution of patients with the geographical conditions.

**Index Terms-** Database based GIS, Patients referral and Matale District.

## I. INTRODUCTION

Health data are concerned with people's health experiences. Health care providers such as emergency departments, hospitals, clinics, and care facilities are responsible for the health security of people. Health data cover a wide range of areas, including inpatient, outpatient, survey, and laboratory, and facility, demographic, socio-economic, and geographical or environmental information. And geography plays a vital role in health care, my aim is to analyze patient's data of Matale (General) Hospital who has diseases born with the relationship of geographical condition of Matale District. Environmental conditions can be air pollution observations, air temperature, and water quality. But my main focus is on water quality. Since ancient times, people realize that diseases in humans and animals are associated with location. For example, Marco Polo became aware of hoof diseases in animals that had consumed selenium-accumulating plants and suffered physical abnormalities, and he believed the cause was the local water supply in given areas [National Research Council (U.S.), 2007]. In the 19th century, Dr. John Snow discovered that deaths associated with the major cholera outbreak in London were located around specific water pumps (subsequently found to be contaminated) by introducing

the locations of disease outbreaks into his analysis. At different locations on the Earth, variability in natural earth processes, environmental quality, ecological issues, and human activities are likely to affect human health. Throughout history, many geographical studies on health activities have been explored.

## II. STUDY PROBLEM

In spite of the continuous development of geographical health applications, the following problems still need to be handled: Firstly, the methods to generate maps from health related activities need to be considered because as far as my knowledge is considered there are no maps to locate the patients or maps that are connected with the data of the patients.

Currently all details of patients are stored in separate files with identification number. If there are any inquiry regarding patients' disease, they use patients' file. Arrangement of All those files are done according to the registration of patient's number, after that arrangement according to the patient's disease is not done. So if they encounter some emergencies with diseases which are infected due to geographical conditions and if they need to find some patients' reports regarding these issues, they will need to make more effort to find them. Nowadays doctors have more concern about most of the diseases infected due to the geographical changes or pollution. For an example, I encountered the following experience in my data gathering period.

When I was seeking some evidence for diseases which are infected due to geographical conditions, a medical student mentioned that they meet patients who have same kidney ailments mainly due to the water quality in Wilgamuwa. Generally pure water has a pH value close to 7 and solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. There is an assumption that they face many kidney ailments because of fluorite solution in drinking water.

Many Data analysis have done about this subject and although doctors are aware of these diseases and their reasons still there are no access for them to study the area which is discussed above. They need to attend seminars or go through experiences of other persons. But due to their busy work schedule, they have limited options to update their knowledge about these areas. Finally the health care practitioners cannot come to an assumption because most of the data are in scattered forms and lack of attempts to organize patients' data and their locations. They have come to an assumption that most of the patients are recorded in Wilgamuwa divisional secretariat (Figure 1). Unfortunately there is no system or technology to find about the

high risk areas and low risk areas in this divisional areas. The medical practitioners can attend to this problem if only they are provided with the distribution of the patients. Data analysis has been done by the data entry technicians in Matale district but not the distribution. So it is obvious that they cannot reduce the number of kidney patients coming from Wilgamuwa Divisional secretariat without acknowledging the distribution of patients. Moreover most of the critical condition patients are directed to Mahiyanganaya, Kandy and Polonnaruwa hospitals due to the lack of facilities.

Though most of the kidney patients are provided with a small ICU and scan. They are conducting clinical but with minimal facilities.

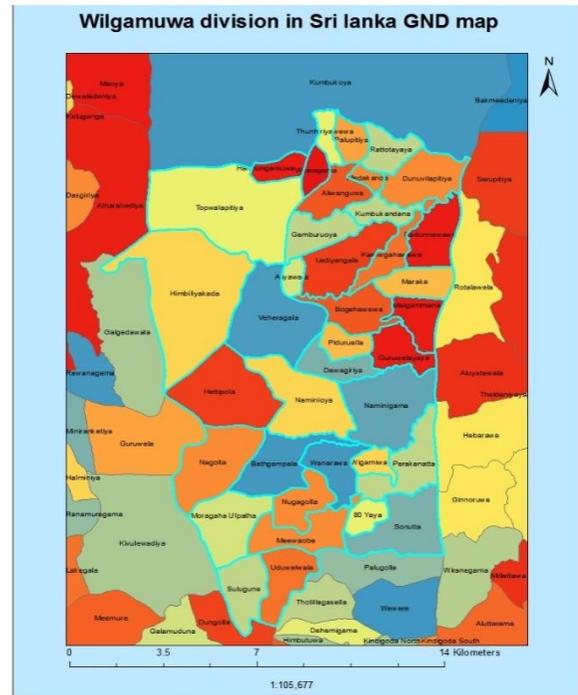


Figure 1: Wilgamuwa Division in Sri Lanka GND Map.

### III. OBJECTIVES

#### A. Well analyzed patients' information

Matale (General) Hospital meets lot of patients daily. So after collecting the patients' data and analyzed details helps to identify patients' kidney diseases and according to this project concepts, it will help to identify all the patients' kidney diseases which are related to geographical changes. Most important thing is, these well analyzed data (Information) helps to treat patients accurately and make pre-safety for patient's living areas and neighborhoods.

#### B. Advanced Health Administration System in Hospital

Well analyzed patients' information led the foundation to advanced health administration in Hospital. Authorities can make use their time to administrate patient treatment through the well analyzed updating information. As we know, Matale (General) Hospital is the capital hospital for Matale district, so the authorities can also use these well-defined Information to treat patients accurately, to direct the patients to regional hospitals (Wilgamuwa and Hettipola). The administration can enhance the facilities and they can direct the patients to the above mentioned hospitals and they can treat emergency cases in Matale hospital. This will make reduce the rush of treating the patients. Moreover most of the critical condition patients are directed to Mahiyanganaya, Kandy and Polonnaruwa hospitals due to the lack of facilities. Though most of the kidney patients are found in Wilgamuwa and Hettipola areas in Matale district, Wilgamuwa and Hettipola hospitals are provided with a small ICU and scan. They are conducting clinical but with minimal facilities.

#### C. Foundation for Further Researches

This project outcome covers the diseases which are born from the geographical changes in Matale district (Wilgamuwa Divisional secretariat). So standard methods used in this research will help to find more solutions for diseases on other areas too. And most important thing is through the result of this project, we can establish researches to find more details about relationship between diseases and geographical changes. Most important advantage is, data can be updated regularly because hospital is receiving clinical data from regular patients until the end of their treatment.

#### D. Paths to Aware From Diseases

Well analyzed data and mapped details helps to identify the development of diseases and these data really help to find pre-safety methods. So treatments also can develop and people can be advised to be aware of these diseases. Through that we can develop ideas to protect and recover environment which faced for geographical changes and effects. Furthermore the facilities regarding Kidney ailments can be improved in Wilgamuwa and Hettipola hospitals.

#### E. Effective Staffing

Always well analyzed information helps to manage staff very effectively. Outcome of this project too helps for hospital staff to manage patient details and make treatments very effectively.

#### IV. SIGNIFICANCE OF THE STUDY

Kidney disease is defined as either kidney damage or decreased kidney function for a period of three months or more. It is an emerging health problem all over the world. The disease is often associated with poor prognosis and it incurs economic burden on the patient, family, community and the country as a whole. Sri Lanka is an island in the Indian Ocean below the southern tip of India with a special topography. The island with a landmass of 65,525 km<sup>2</sup> has a central massif with its tallest peak rising 2,500 meters above sea level.

In early nineties investigators in Sri Lanka have found an alarmingly high incidence of kidney disease in the province, Matale district of Sri Lanka. Usually kidney disease is related to the causes such as diabetes mellitus, hypertension and infection, but it is lately found out that the patients of Matale district are not related with above causes. When observing the Wilgamuwa area, we can propose a number of risk factors including high level of fluoride in ground water, heavy metals such as cadmium and exposure to inorganic pesticides.

Geographic information systems (GIS) and geographic position system (GPS) are computer-aided database management and mapping technology that organizes and stores large amounts of multi-purpose information. GIS is particularly useful to health professionals and administrators in planning and day-to-day management. It offers powerful tools to determine geographical distribution and variation of diseases, and their prevalence and incidence. GIS and GPS are used in this research mainly due to above reasons.

In this study, I attempted using GIS and GPS technologies to study the geographical distribution of Kidney disease patients in Wilgamuwa division. The present study was carried out with the aim of studying demographic characteristics of the patients, geographical distribution of the disease, location of households of kidney disease patients in relation to reservoirs, irrigation canals and the topography of the affected area that would help identify potential etiological factor/s, which could be associated with the disease.

According to the 2010 Global Burden of Disease study chronic kidney disease was ranked 27th in the list of causes of total number of global deaths in 1990 (age-standardized annual death rate of 15.7 per 100 000), but rose to 18th in 2010 (annual death rate 16.3 per 100 000). By contrast to the developed countries, infectious diseases continue to be prevalent in low-income countries, secondary to poor sanitation and inadequate supply of safe water.

GIS and GPS are important tools to link patient or population location to information. This review provide an overview of basic GIS concepts and provide examples to illustrate how GIS techniques have been applied to the study of kidney disease, and in particular to understanding the interplay between rural residence and the geographical or topographical issues. Recent publications have explored the relationship between socioeconomic factors and kidney disease. Geospatially fluent analytic approaches can inform system level analyses of health care systems and these approaches can be applied to identify an optimal distribution of kidney patients. GIS analysis could help untangle the complex interplay between geographical factors and chronic kidney disease. Kidney diseases are found mainly in the north central province in Sri Lanka. The data analysis shows that

there is a considerable amount of patients in Matale district, particularly in Wilgamuwa divisional secretariat. So this study is done in order to find out the distribution of kidney patients and to fathom the relationship between geographical factors and the increment of kidney patients.

#### V. METHODOLOGY

##### A. STUDY AREA

An area covering 971 km<sup>2</sup> lying between 7.31 07 20N – 7.37 46 68N latitude and 80.56 55 24E – 80.55 10 40E longitude in Wilgamuwa, Matale was selected for the main study.(Figure 2) The climate of this region is a difficult climate since the area belongs to the dry zone, with an estimated annual rainfall of 2500 - 3000 mm. According to weather station readings, daily mean temperature is 25°C. All these conditions favor spread of this disease in Wilgamuwa division (Figure 3).

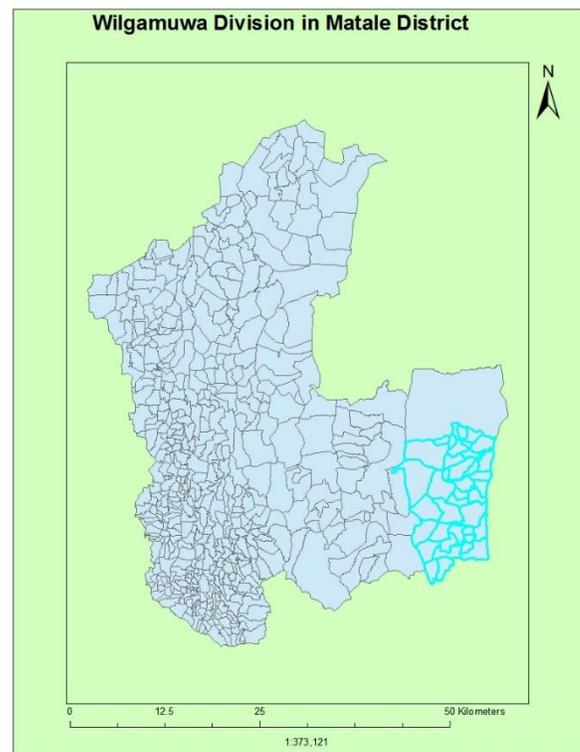


Figure 2: Wilgamuwa division in Matale district.

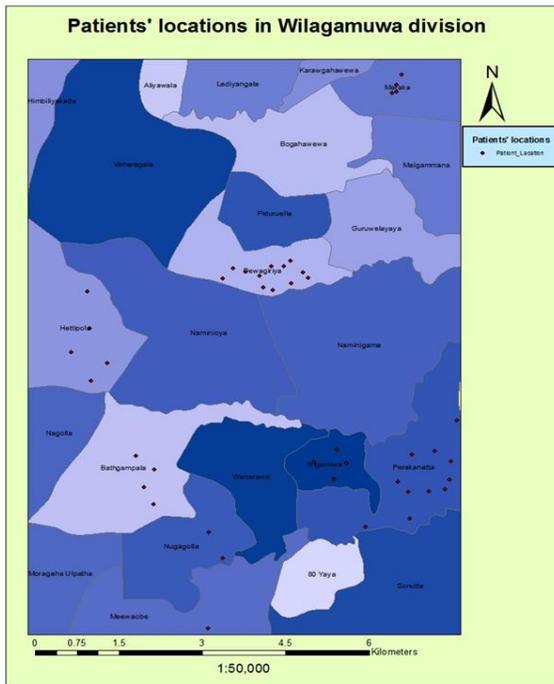


Figure 3: Patients' locations in Wilgamuwa division.

**B. DATA COLLECTION METHODS**

- Discussions with the Doctors in Matale (General) hospital lead the way to do a research about Kidney disease patients in Matale. Frequent discussions with them were helpful in identifying Wilgamuwa division as the area, from where most of the patients come.
- As a result, patients' locations in Wilgamuwa division were collected from the hospital.
- Information was collected with reference to respective addresses of 66 chronic kidney disease patients who attended community clinics in Matale (General) hospital.
- Homes of these patients were visited to record the GPS coordinates and to reconfirm the diagnosis using documentary evidence.
- In the first part of the study GIS mapping was used (ARC 10.1 software) to study the geographical distribution of the disease.
- The patient density per each Grama Niladhari Division (GN) was calculated using the ARC 10.1 software.
- Based on the findings of the GIS mapping, the area Wilgamuwa division with multiple small reservoirs was selected for further studies.
- GPS mapping was used to study the location of kidney patients in relation to reservoirs, irrigation canals and the topography of the selected area.
- The coordinates were plotted in to ARC 10.1 software using a Microsoft excel sheet.
- For conducting a GIS-based analysis of the spatial distribution of kidney patients, the coordinate point and polygon layer was generated based on the Grama Niladhari Division (GND) map.

**C. DATA ANALYSIS**

When analyzing the collected data, Microsoft excel sheet was created to arrange the data of patients' name, age, sex, occupation and coordinates. First of all, Wilgamuwa DSD was clipped from Matale district map as Wilgamuwa Division is the study area. The Microsoft excel sheet with the longitude and latitudes was plotted in to the ArcGIS surface. Then the Wilgamuwa division map with GND was plotted in to the surface. After plotting the coordinates in to the map, hotspot analysis was done using a model builder. Hotspot is defined as a condition indicating some form of clustering in a spatial distribution. This has led to use of the Getis-OrdGi\* (d), which can separate clusters of high values from cluster of low values. Moreover, clusters of cases that occur randomly can also have an influence on the spread of an infectious disease. In the map, darker areas indicate statistically significant hotspots, while, light areas represent significant cold spot areas. IDW interpolation method was used to produce predictions of incidence rates kidney disease cases across the whole district. The IDW interpolation technique is commonly used in GIS programme for producing surfaces using interpolation of scatter point and has been employed in other analysis of vector borne disease. IDW is used to interpolate and predict the pattern of kidney disease distribution across the district. The use of IDW method is to give more weights to nearby points rather than to distant points. The IDW method is an exact method and it is a more accurate one which gives more weights to nearby points rather than to distant points

**VI. ANALYSIS**

The information showed that the "male: female" ratio of the disease was "15: 7" Kidney disease is more prevalent in the age group over 40 years (Figure 4). Out of the total, 90% of the patients were farmers. The source of drinking water was shallow wells (92%). Kidney disease was present even among patients who consumed boiled water and used for cooking purposes.

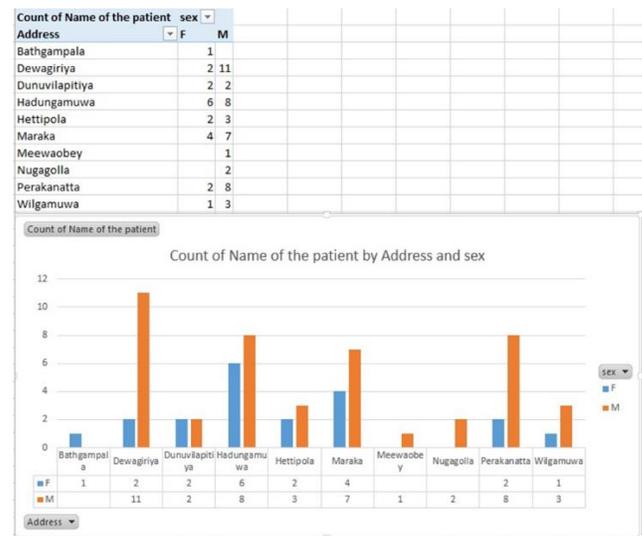


Figure 4: Age and Sex Distribution of Kidney Disease Patients in Wilgamuwa Division.

The analyzed data indicated three high prevalent areas in Wilgamuwa division, namely Dewagiriya, Hadungamuwa and Maraka.

Figure 5 shows the distribution of patients in Wilgamuwa division. Dewagiriya is mainly a paddy farming area that is supplied by Dewagiriya, Oggomunawewa, Kudawewa, Dunuwilawewa and Aliyawelawewa. Hadungamuwa is also a paddy cultivated area which is supplied by Dumbarawewa, Talagiriya and Kadurapeliya irrigation canal. Maraka is also supplied with Karawagahawelwewa and Galwalaoya. The whole Wilgamuwa area is supplied with the branches of Mahaveli River and Minipe irrigation channel. GPS mapping shows that most of the affected villages are below the reservoir or canals (Figure 6). Area with the lowest altitude is affected by the disease.

The geographical distribution of the kidney disease shows that the disease is confined to some areas of the dry zone predominantly in the Central province, Matale district, Wilgamuwa division, which includes number of GND. A large number of patients have been detected in Wilgamuwa and Hettipola areas. It has been observed that Dewagiriya, Hadungamuwa, Maraka and Perakantta are high risk areas in Wilgamuwa division. (Figure 7). After doing the hot spot analysis, it was obvious that Hadungamuwa area was in a high risk from above mentioned four risk areas (Figure 9).

The area encompasses a well-developed Minipe and Kadurapeliya irrigation system comprising of either one or two large reservoirs (Dewagiriya and Dumbara) or a cluster of small reservoirs. Water from these reservoirs is mainly used for agricultural purposes, particularly for paddy cultivation (Figure 8). Moreover, the people who live in these areas consume water and use for day to day chorus from shallow wells. These shallow wells are purposely built close to the irrigation canals so that the dwellers can gain water without digging too deep. And the most important thing is that most of the shallow wells are downstream of the irrigation canal. Water levels of these shallow wells are similar to the water levels of the irrigation canals. Therefore, the ground water level fluctuates simultaneously with the water level of the reservoirs and canals. So it is obvious that the water flows from these canals to the shallow wells. On the other hand Himbilyakanda is a GND in Wilgamuwa district but there are no records of kidney disease patients because they are neither supplied with irrigation canals nor reservoirs and they are using natural spring water for drinking and cooking.

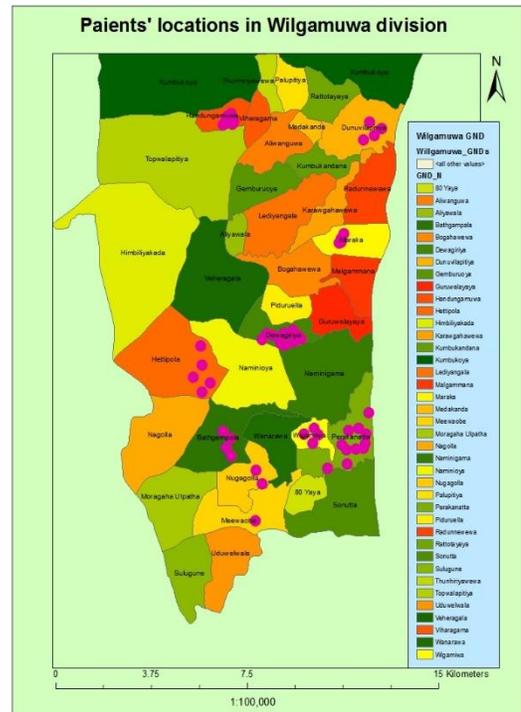


Figure 5: Locations of the Households of Kidney Patients in Wilgamuwa Division



Figure 6: Distribution of Water Reservoirs and Irrigation Canals in Wilgamuwa.

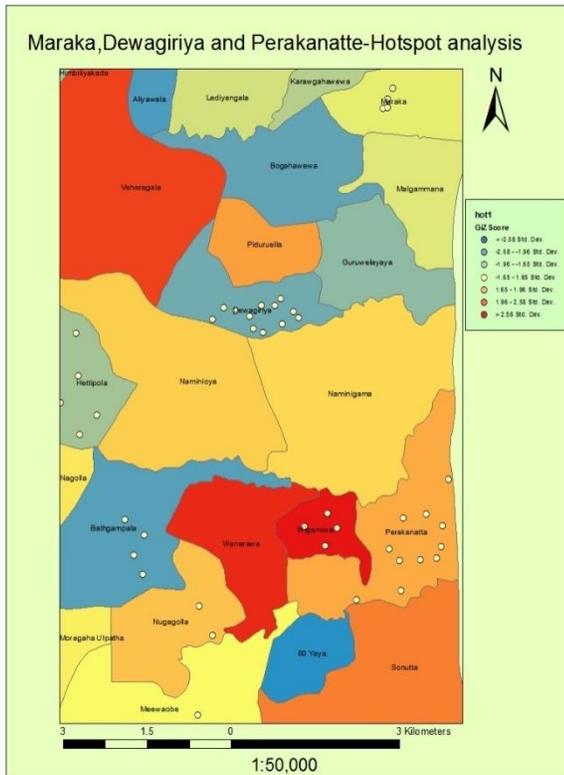


Figure 7: Hotspot Analysis Results

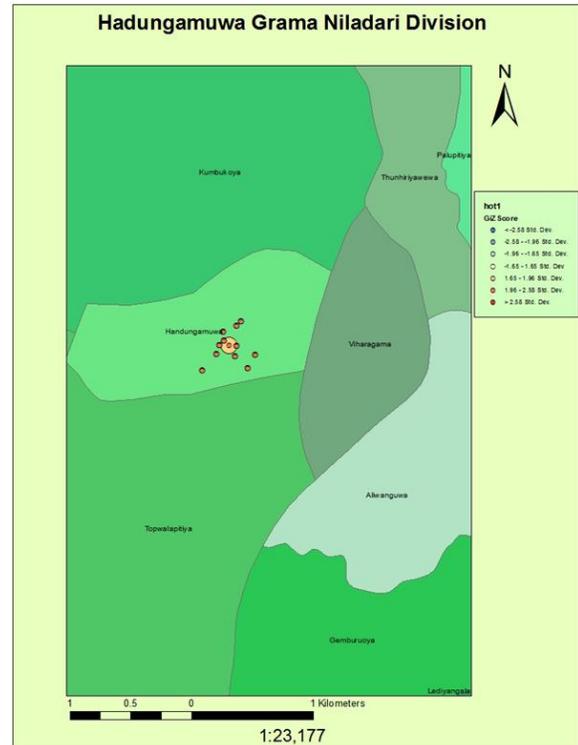


Figure 9: Hotspot Analysis. Hadungamuwa GND with Large Amount of Patients

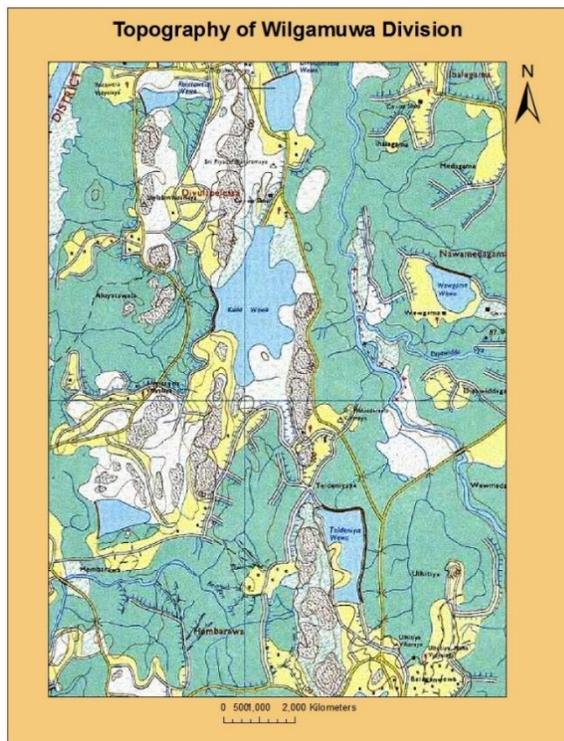


Figure 8: Paddy Cultivation with Water Reservoirs in Wilgamuwa.

## VII. CONCLUSIONS AND RECOMMENDATIONS

### A. CONCLUSIONS

It is obvious from this report that the siblings of the kidney patients tend to have kidney diseases not because of the direct genetic/inherited background for the disease but from the exposure to the etiological reasons. Disease spreads in males than female may be due to their frequent exposure to the etiological reasons than females. This could be because almost all the patients are farmers in occupation. In conclusion it is not hard to realize that the geographical distribution of the disease is related to the irrigated water which implies the possibility of an environmental or geographical factor related to water in spreading the disease. More or less it is connected to the water quality of the area. It is proven in the research that the use of water from the shallow wells for drinking by the affected population indicates the possibility that the etiological agent is water soluble.

The data analysis or this research report show practical kidney control measures, as well as methods for future study of kidney diseases. Further, GIS, GIS-based spatial statistical techniques and GPS may provide an opportunity to clarify and quantify the critical situation of Kidney within this areas, and lay a foundation to pursue future investigations into the environmental factors responsible for the increased disease risk. To implement specific and geographically appropriate risk-reduction programs, the use of such spatial analysis tools should become an integral component in research and risk assessment of Kidney disease.

### B.RECOMMENDATIONS

Using this research report, the administration can implement kidney risk reduction programs in these area to prevent further risk. The medical administration can launch community health clinics to educate the public about the measures that they should take in order to reduce future kidney disease. It is obvious that the water flows from the canals to the shallow wells, since this is a crucial point, it is high time that the administration should pay attention to the irrigation projects and to these shallow wells. Public should be informed of the fact that they get kidney disease because of they are consuming the water of these shallow wells. Since the area is a paddy cultivated area, the villagers are farmers in occupation. So it is clear that one cannot alter their living hood but the administration can pay heed to this crucial fact and they can give options for them.

One option is that the administration can implement a “proposed water distribution system” to distribute drinking water. The water board can launch a project where they will filter the water using chemicals and they will distribute water using pipe lines to this high risk area. So the public can use pipe line water only for drinking and cooking purposes. It takes a little time to propose this kind of projects, estimate a budget, and make a plan and to launch the project. So it is better to distribute water cans while the project is being launched.

While taking measures to prevent future risk kidney disease and to reduce kidney disease, the health administration can implement projects to enhance the facilities in Wilgamuwa and Hettipola hospitals. Since there is only a small Intensive Care Unit (ICU), Scan unit and clinics in these above mentioned hospitals, it is high time that the administration should enhance the relevant facilities to treat the kidney patients. Often the kidney patients are directed to Mahiyanganaya, Kandy and Polonnaruwa hospitals to get treatments. In that process, the patients encounter numerous problems. Since they are having poor income, they cannot afford to travel to the clinics and also some of the critical condition patients die in the process of transferring from hospital to hospital. So this research report can be used to perform above mentioned recommendations.

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### AUTHORS

**First Author** – Panamaldeniya Mudiyansele Chathurika Senanayake, BA (General) English, University of Sri Jayewardenepura, Sri Lanka  
[chathurika\\_senanayake@yahoo.com](mailto:chathurika_senanayake@yahoo.com)