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Spatial Assessment of the Recorded Incidents of Mud on the Road in Herefordshire

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Abstract- The deposition of mud on the road has serious consequences including contributing to serious and fatal accidents. The objective of this paper was to assess the correlation between reported occurrences of mud on the road in Herefordshire and spatial and temporal factors that may have contributed to the risk of mud ending up on the public highway. Relevant datasets including incidence data (mud on road) from Herefordshire County Council, land use, soil data, erosion risk, slope and data through Digi map online, were combined and spatially analyzed using a GIS (Geographical Information System) software. The results indicated that the highest numbers of mud incidents occurred between October 2013 to April 2014 and 83% of these cases occurred in areas with high erosion risk. The land use data showed that 42% of Herefordshire was arable. Soil data showed that over 74% of the soil texture was silt clay loam which is suitable for arable farming. The data also showed that as rainfall increased mud incidents increased.

Keywords: *land use; mud incidents; rainfall; soil texture; slope, erosion.*

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Abstract- The deposition of mud on the road has serious consequences including contributing to serious and fatal accidents. The objective of this paper was to assess the correlation between reported occurrences of mud on the road in Herefordshire and spatial and temporal factors that may have contributed to the risk of mud ending up on the public highway. Relevant datasets including incidence data (mud on road) from Herefordshire County Council, land use, soil data, erosion risk, slope and data through Digi map online, were combined and spatially analyzed using a GIS (Geographical Information System) software. The results indicated that the highest numbers of mud incidents occurred between October 2013 to April 2014 and 83% of these cases occurred in areas with high erosion risk. The land use data showed that 42% of Herefordshire was arable. Soil data showed that over 74% of the soil texture was silt clay loam which is suitable for arable farming. The data also showed that as rainfall increased mud incidents increased. It could be inferred that the major driving factors of mud incidents in Herefordshire are land use, soil type and rainfall.

Keywords: land use; mud incidents; rainfall; soil texture; slope, erosion.

I. Introduction

The intentional or unintentional deposition of mud on the road is an offence in the UK (Highways Act, 1980). As well as being illegal, deposition of mud on the public highway has serious consequences including serious and fatal accidents. In rural areas most incidents are often apportioned to farming operations primarily, accessing land to harvest a crop in less than favorable conditions, and subsequently driving the vehicle on a public highway (Cornwall Council, 2014). Soil properties vary naturally across the landscape (Campbell, 1979). Spatial variability in soil properties particularly soil texture may, therefore, account for spatial variability of occurrence of mud on the road because, for example, of their variability in stickiness (as affected by clay content) and also because of the associated crops grown in a particular soil type.

Mud on the road is believed to be caused by heavier vehicles such as tractors, trailers and Lorries, the risk of this is increased following significant rainfall (Cornwall Council, 2014). Mud on Herefordshire roads is believed to be putting lives at risk by causing dangerous situations (West Mercia Police, 2012). Farmers were warned not to leave mud on the roads after three accidents in Herefordshire, when the West Mercia Police had no option than to close three A roads (BBC England, 2012). Mud on the road was also blamed for a crash that killed a mother and son near Leominster in February 14, 2012 (Hereford Times, 2012). Various factors are expected to have a major influence on the incidents of mud on road. These ranges from; land use, crop type, the design of the road, slope of the area, and the vehicle tire/track design.

Mud can occur as a suspension of solids concentration. Muds can be homogenous, as in the case of a well-mixed suspension or a rapidly emplaced bed, or exhibit strong vertical gradients in mechanical properties due to self-weight consolidation (Dade et al., 1992). Soil is at sticky point when it is just wet enough to cling to a foreign material across its surface (Fountaine, 1954).

The adhesion force is mainly due to the water film at the contact surface between the soil and the material (Wang et *al.,* 1998). According to Gill and Berger (1967) the water films thickness is determined by soil properties, moisture content and the roughness of the material's surface. Since vehicle tyres are design for higher adhesion to the soil to reduces the tendency of slipping or skidding, adhesion of mud to tyres is very likely to happen which increases the risk of mud being transported from a field.

II. Materials and Methods

a) Geographical Location of Herefordshire

Herefordshire is an English county in West Midlands, with a land area of 2,180 sq. km, located at Latitude 52.08 and Longitude -2.75. Herefordshire is one of the most rural and sparsely populated counties in England, with a population density of 82 km^2. The M50 road runs through the south of the county. The hilly nature of the terrain in mid Wales means that the ground transport links between North Wales and south Wales run through Herefordshire. The other trunk roads in Herefordshire are the A49 and A465, which form part of these north-south routes across the county as well as catering for local traffic.

b) Soil

The underlying geology of Herefordshire is predominantly Old Red Sandstone, which is relatively

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permeable material therefore leading to well-drained soil ideally suitable for agriculture. The soil series comprises well drained reddish brown or brown very fine and fine sandy loams and loams overlying fine grained Devonian sandstone rock (Mathew, 2009). The parent material is of variable colour but mainly reddish brown, fine grained micaceous sandstone which is sometimes thinly inter bedded with siltstones or marls and may be slightly calcareous.

c) Land Use

The study area is predominantly arable land. In recent times arable land has led to an increase in erosion and over a third of the arable land in the UK is likely to erode (Robinson and Blackman, 1989). Large farms are found mainly on the wide, flat floodplain and terraces of the Wye Valley and on the sandy soils of the southernmost parishes of Herefordshire.

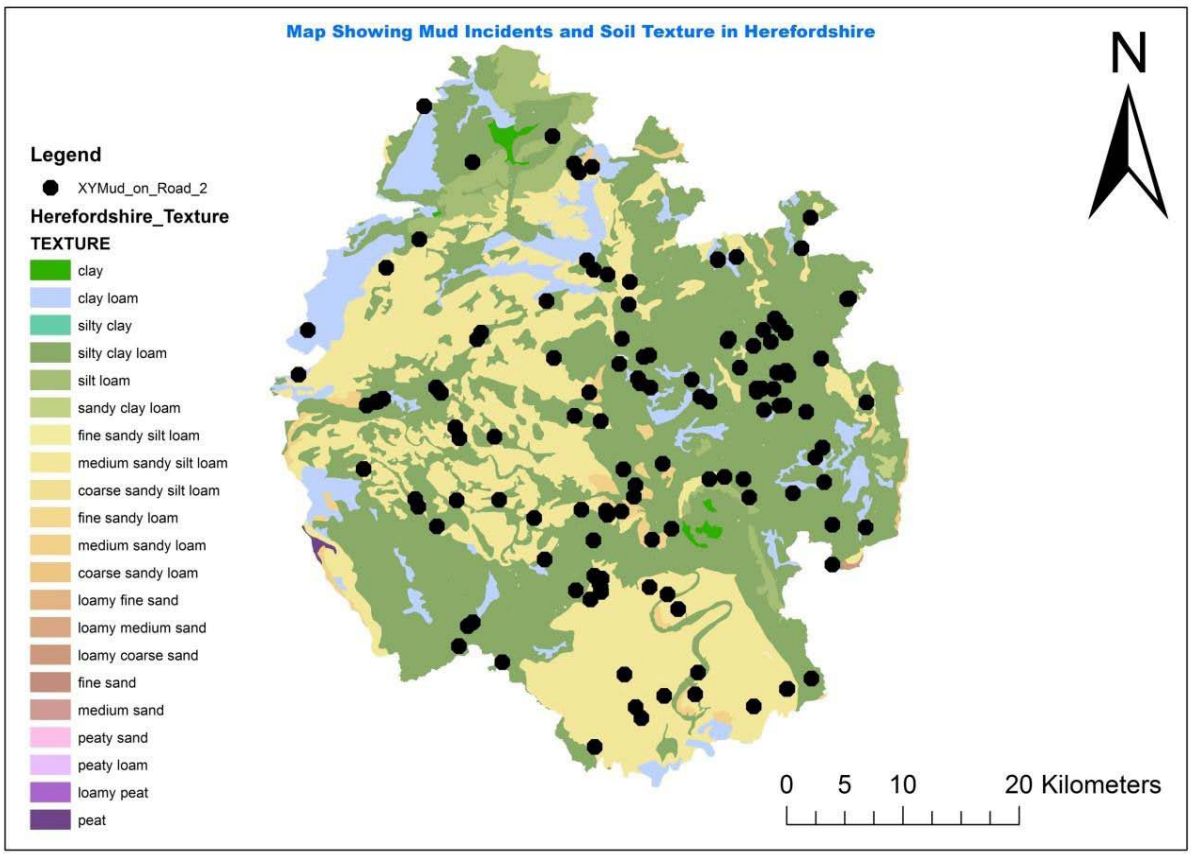

Figure1 : Mudincident sand soil texturein Herefordshire

Figure 2 is a map showing mud incidents in relation to soil texture in Herefordshire. The incidents were dominant in areas with silty clay loam. This could be because it also covers the greatest land area of 74%.

d) Data Analysis

In order to achieve the set objective, relevant datasets were collated including incidents data (mud on road) from Herefordshire County Council, land use, soil data, erosion risk, slope and data through Digi map online. The above data was spatially analysed using GIS (Geographical Information System) software, and ArcMap version 10.2. The mud incidence data was spatially joined to other data sets to evaluate the corresponding factors contributing to the mud on road incidents. The data was graphically plotted using Microsoft Excel 2007 in order to identify the major factors contributing to mud on the road in Herefordshire. The recorded locations of mud incidents were also viewed using Google Earth in order to assess terrain features.

III. Results and Discussion

Analysis of mud on road incidents recorded by Herefordshire Council between September 2013 and June 2014 shows that mud incidents occurred mostly during October-December, and least during May and September (Figure 3). The result may be due to accessing the farm for various operations during the autumn, winter and early spring. The low occurrence of incidents in September may be due to incidents not being reported.

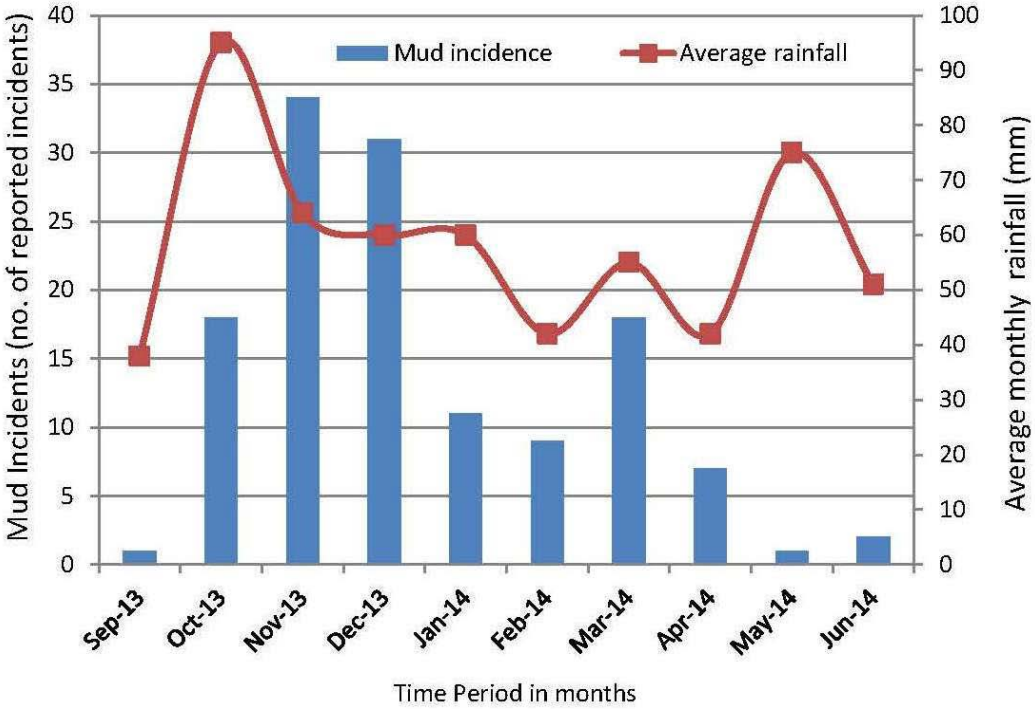

Figure 2 : Bar chart of Mud on road incidents with reference to months of the year they occur (total number of incidents=132) and monthly rainfall (mm).

The analyzed spatial data suggests that the reported incidents of mud on road (Figure 2) were highest from October-December and lowest in May. These incidents of mud on road were reported to have been caused by farmers harvesting potatoes (West Mercia Police, 2012). This period (October - December) coincided with intensive arable farming operations (harvesting of potatoes, harvesting of sugar beet, plowing, and transporting of feeds for livestock).

Figure 3 and Table 1 shows the frequency of mud on road with respect to land use (RPA dataset 2010) in Herefordshire and the references codes. Most of the mud incidents occur in areas were crops such as wheat, barley, maize and annual fruits and vegetable crops were cultivated. High incidents of mud on road in arable land may be due to accessing the land for various operations including late harvesting of potatoes and maize and drilling of winter wheat, oilseed rape and barley.

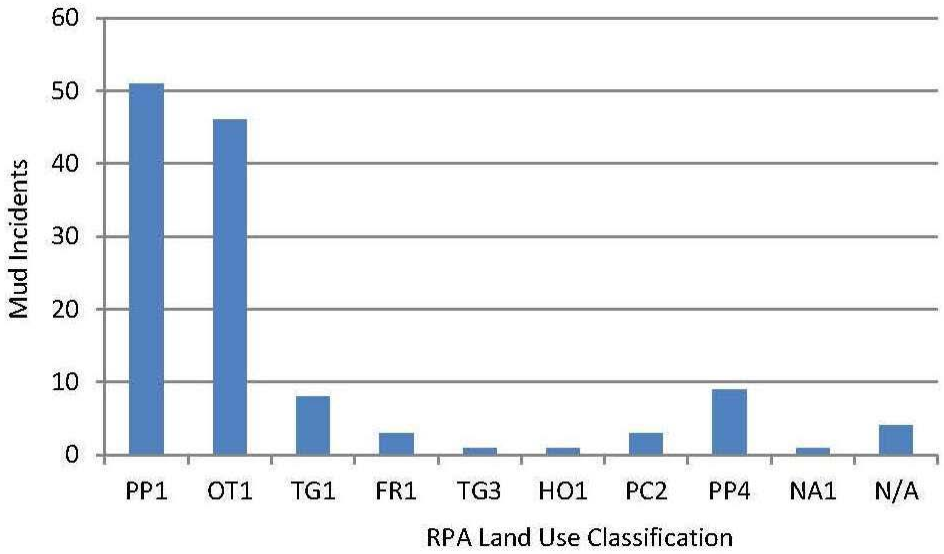

Figure 3 : Relationship between mud incidents and land use (see Table 2 for land use codes) (RPA dataset 2010)

Table 1 : RPAlanduse (2010)code and their code references

Land use code	Code references
PP1	Permanent pasture land including grazed woodland
OT1	Field use for crops such as wheat, barley, maize, and annual fruits and vegetables crops
TG1	Temporary grassland field
FR1	Forest/woodland area
TG3	Temporary grass land field area
HO1	Field used for planting Hops
PC2	Permanent fruits and vegetable field
PP4	Permanent pastureland
NA1	Land in non-agricultural activities for more than 28days
N/A	Not available

Establishing relationships between parameters such as vegetation cover, rainfall, runoff and soil loss is challenging (Zokaib and Naser, 2012). The rainfall was highest in summer but the frequency of reported mud incidents was higher during the autumn, winter, and early spring. According to Robinson and Blackman (1989) there is a higher tendency of erosion in areas of arable cultivation during autumn, winter and early spring. Monthly runoff and soil losses are expected to be higher from summer to autumn due to high amount and intensity of rainfall.

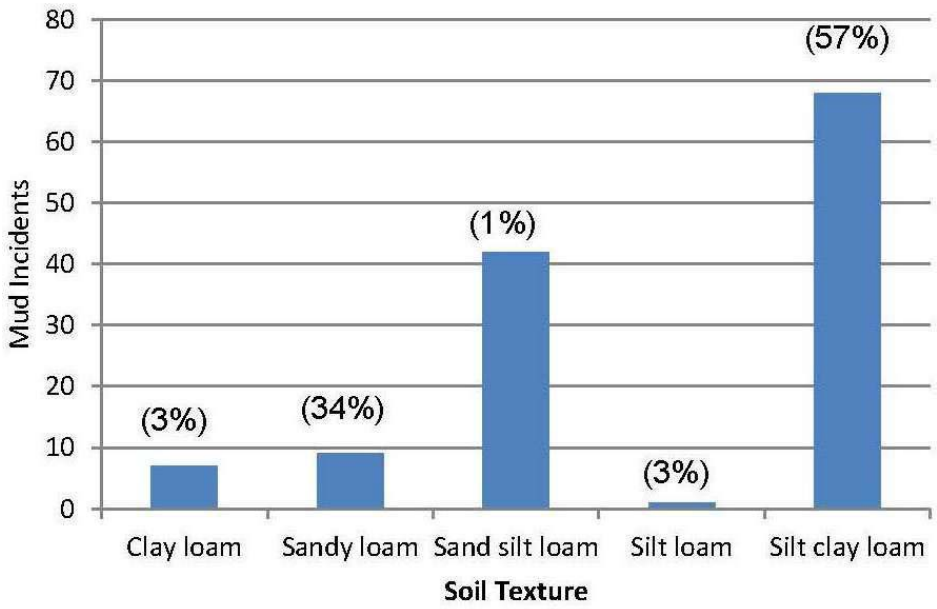

Figure 4 : Relationship between mud on road incidents and soil texture (percentage area of soil texture in catchment shown in brackets).

From Figure 4 it can be seen that the highest occurrence of mud incidents (n=68) occurred in silt clay loam textured soils. The second highest occurrence of mud incidents (n=42) occurred in sandy silt loam soils. Silt loam soils had the least value of mud incidents. This suggests that mud incidents has had a greater occurrence in areas with silt clay loam type soil texture.

Figure 5 shows the relationship between frequency of mud on road and the slope of the terrain in a range of classified slope (°). The slope was classified for easy interpretations as the mud incidents occur across a wide range of slope. Mud incidents are seen to be highest in areas that are relatively flat, which is between 0° to 9°. There may be several reasons for this. From the plot the trend of relationship between mud incidents and slope gradient of the terrain tends not to follow the same trend. There seems to be a negative relationship between slope and mud incidents.

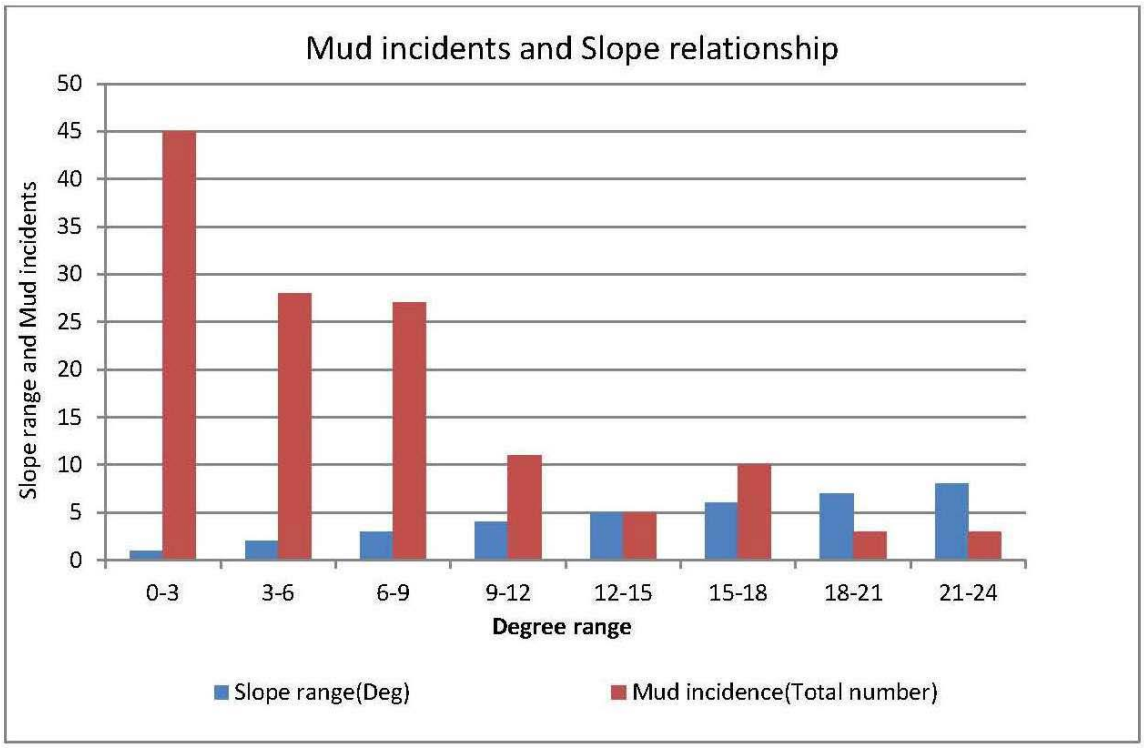

Figure 5 : Relationship between mud incidents and slope

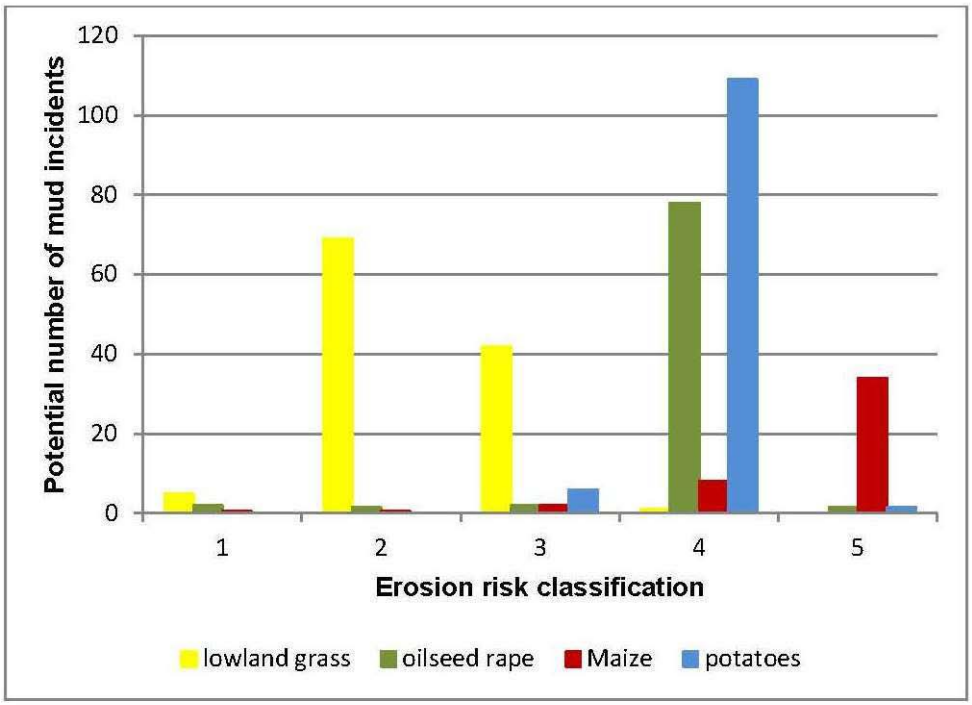

Figure 6 : Mud incidents and Erosion Risk Relationship: X axis represents Erosion risk classification (see table 3)

Mud incidents and erosion risk relationship is shown in Figure 6 using the reclassified values as shown in table 2. The layer data output was reclassified due to some unusual negative and very high values of the output data layer of erosion risk obtained for Herefordshire. The figure shows the erosion risk with the following crops e.g. potatoes, maize, oilseed rape and low land grass in relation to the reported mud incidents in Herefordshire. Assuming that the following crops were planted in the locality of the reported mud incidents,

approximately 83 % of the mud incidents occurred in areas of high erosion risk for potatoes and 78% for oil seed rape. Twenty six percent of the mud incidents occurred in areas of very high erosion risk for maize, while approximately 32 % of the mud incidents occurred in areas of low erosion risk for lowland grass. The high incidents of reported mud on road in areas of high erosion risk with crops such as potatoes may be due to late harvesting between September and October when the soil was wet and therefore more adhesive to vehicle wheels (Pickersgill, 2001).

Table 2 : Reclassified range of erosion risk data.

Erosion risk (t ha^{-1})	Reclassified values (t ha^{-1})
<0.5	1-very low risk
0.5-1.0	2-low risk
1.0-2.0	3-moderate risk
2.0-5.0	4-high risk
>5.0	5-very high risk

Table 2 shows the reclassified values of erosion risk. Less than 0.5 is classified as (1-very low risk) between 0.5 to 1.0 is classified as (2-low risk), 1.0 to 2.0 classified as (3- moderate risk) between 2.0 to 5.0 classified as (4- high risk) and greater than 5.0 classified as (5- very high risk).

IV. Conclusion

The results of the slope and texture of the area shows suitability of the area for arable farming, it is important that the resources are not over utilized and therefore degraded in order to prevent incidents of mud ending up on the road.

Incidents of mud on the road have become an environmental menace in Herefordshire. It is important to identify which kind of land uses will be more suitable to address the issue of mud ending up on road in terms of crops combinations, this research should be site specific. Well-designed land uses, based on scientific information, will be crucial in reducing mud on the road by reducing soil erosion or sediment build up which could be transport to the road by vehicle movement. Site specific research will be required in the future in this regard. It is only suspected at the moment that the current land use (arable) which dominates the area is a primary contributing factor to mud ending up on the roads in Herefordshire.

V. Recommendations

The following measures are recommended:

1. Improving the aggregate stability of the soil.
2. Increasing the infiltration capacity of the soil to reduce runoff
3. Ensure the soil surface is cover to protect the soil from raindrop impact
4. Planting of buffer strip to reduce runoff from field
5. Changing the gate position if the field slopes towards the gate.
6. Consider land use change
7. Better enforcement of the 2005 single payment scheme.
8. Culverts, gulley's and drains needs regular monitoring and maintenance by all relevant stakeholders (i.e. farmers, council authorities, landowners, the police and the environmental Agencies).
9. The farming calendar should be cross check with monthly pattern of erosivity in the area to see how well the soil is protected from degrading.

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