The Political Economy of Land Degradation: Developing a Research Framework

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Abstract

As our population continues to rise from seven billion, the amount of arable land on the planet remains constant. Though land is still available to bring into production, its supply is dwindling and increasingly coming into conflict with environmental or social interests. With a dwindling supply of land, preservation of land currently employed in agriculture is beginning to mean more and more in peoples everyday lives. In sub-Saharan Africa in particular loss of productive land through land degradation threatens the food security of individuals who subsist via farming their land or earning a wage working on a farm. These farmers are responding to the incentives provided to them by both markets and governments, and the current state of affairs indicates that these incentives are not adequate enough to warrant farmers' investment in conservation. This research is focused at identifying whether the economic environment created by government policy significantly affect the incentives farmers have to employ conservation techniques by looking examine relationships between degradation severity and food exports/imports, food aid, and structural adjustment programs. The results of the research show that the standard deviations of exports have a significant relationship to land degradation severity, implying that change in land practices may contribute significantly to process of land degradation. While the results are promising the process of unearthing these results reveals multiple difficulties in equating socioeconomic conditions to environmental phenomena. However only by addressing these difficulties can governments effectively take hold of their domestic agricultural regimes and pursue a process of development.

Introduction

As the 19th century dawned Thomas Malthus identified a trend that has long plagued human societies; that population growth tends to occur exponentially and food production occurs linearly. The result of such a divergence is a constant tension between the population and food availability. Malthus claimed that disease and war were the main means by which this system was kept in balance. Unfortunately for Malthus he wrote before the industrial revolution. Following the industrial revolution it became clear that technology could be equally instrumental in mitigating the balance between population and food production. Since then agricultural technologies such as: crop rotation, the steel plough, the tractor, inorganic fertilizers, and the genetically modified seed have continued to contributed a multiplier effect to human food production. However, during this augmentation one agricultural factor has remained constant, the area of arable land available for production.

Process and Effects of Land Degradation

Land as referred to in this research refers to, "spatial units characterized by ownership, resource availability and consumption, policy and economic environments, and boundary conditions." (Eswaran et al, 2003). Land in this sense in a finite resource that must be conserved in order to maintain or augment agricultural productivity. When looking globally it is clear that, "arable land per Capita is declining… because of population growth, conversion of agricultural land to other uses, and soil degradation." (Lal, 2003). To complicate the problem of land availability is the fact that, "Only 16 percent of agricultural soils are free from constraint."(Wood et al, 2003). Due to the limited amount of these favored soils some researchers have estimated that, "nearly 40 percent of the world's agricultural land is seriously degraded, undermining both present and future productive capacity in many regions." (Soule et al, 2003). Land degradation as used above refers to the depletion of the natural endowments of the soil such as chemical composition and soil structure, as well as losses in water resources available to the, and unit. Land degradation though often used in reference to onsite effects has been known to be associated with many negative environmental and social consequences offsite such as water pollution, sedimentation and eutrophication.

Soil Scientists vs. Economists

When assessing the nature of a problem such as land degradation, scholars are generally divided into two interpretations. The first group views land degradation as, "the global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effects on food security and quality of life."(Eswaran et al, 2001). This group is generally composed of soil scientist and the like that view soil as a nonrenewable resource, a nonrenewable resource that is directly related to food price and availability. The second group composed largely of economists, claims that if land degradation did truly affect agronomic productivity then farmers would have incentive to take measures that combat land degradation and it would not constitute external attention. While research can be found to support each claim, the data is not spatially fine enough or broad enough to draw a global conclusion. However regardless of the data it is clear that the, "Economic argument hinges critically on the degree of complementarity between soil quality and other inputs or investments." (Scherr, 2003). These other inputs or investments generally take the inorganic form of mechanization or inorganic inputs but can also manifest themselves in creative solutions such as terraces or the introduction of a new crop or fallow period. While the economic argument has merits, research by Sara J. Scherr indicates that, "substitution of organic inputs with chemical fertilizers has led to declining organic matter and acidification of vulnerable soils." Indicating that the complementarity between various soil inputs is not absolute, therefor strengthening the soil scientist argument that quality soil is a nonrenewable resource.

Food Security

It is clear that land degradation is occurring at rates that vary by region. Whether or not it has implications on food security is a more ambiguous question, a question that can only be answered when looking at the economics of agricultural commodities. In general the, "inelastic demand for agricultural products and inelastic supply of land ensure that agricultural productivity increases tend to lower the price of agricultural goods and shift resources into the non-farm sector." (Masters, 2003). The result being that any gains in efficiency that a farmer creates are experienced by society as a whole and not by the farmer. The result of this market structure is that, "negative yield shocks do not generally increase the price of agricultural commodities, imposing hardships on households that sell their own agricultural production as well as decreasing prospects for agricultural labor." (Hopkins et al, 2003). It is the labor element of this equation that is most important when considering the implications land degradation has for food security.

For all people on the globe, "Access (to food) depends in turn on the supply of food and people's ability to acquire it, both of which are influenced by agricultural productivity. (Wiebe, 2003). Individuals' ability to acquire food depends on the inter-relationship of their income to the price of agricultural goods. This relationship can be made inoperable either by spikes in the price of agricultural goods or a loss of income necessary to acquire these goods. Due to the fact that only, "10 percent of food consumption is traded on international markets," prices in agricultural commodities are, "highly location specific," these prices can remain low in areas where substitution is easy and affordable, but can also increase significantly in regions without the resources to substitute for yield losses (Scherr, 2003)(Wood et al, 2003). The result being that food security problems associated with land degradation are also location specific.

The attributes of a location that predispose it to food security threats via land degradation are the, "the quality and productivity of agricultural inputs such as land and labor." (Wiebe, 2003). In a study concentrating of the productivity of labor Soule et al. identified sub-Saharan Africa as the least productive labor land relationship. Soule's findings along with others indicate that sub-Saharan Africa suffers the greatest productivity and labor income losses from land degradation. This research in conjunction with projections that, "sub-Saharan Africa is projected to account for 80 percent of the future nutritional gap," have led me to focus my research on the sub Saharan African region (Rosen et al, 2003). When examining land degradation farmer's decisions are the relevant variable. These farmers are, "subject to economic and social pressures of the community/country in which he/she lives." (Eswaran et al, 2001) Therefore any effort to understand the mechanisms that cause/prevent agricultural land degradation must consider the sociopolitical pressures farmers face.

Farmers

At the base of each argument concerning land degradation is the role of the farmer. It is he/she or in some cases it (corporations) that decide which practices are to be used on the land. The determination of these practices in conjunction with the inherent characteristics of the land determines the extent of land degradation both onsite and offsite. While offsite effects are outside the economic circuit of the farmer is a part of, the onsite effects directly affect his production either by increasing input costs or decreasing yield. While such a circumstance may create the illusion that all farmers are inclined to use conservation practices, “practices that reduce land degradation and offer higher net returns over time may require initial investments that inhibit adoption in the short term.” (Wiebe, 2003). As a result many efforts that could have conserved the land go unused.

Political Economy of Farmer’s Incentives → Food import vs. Food Export

A main factor influencing the decisions of farmers is the role of government. Through taxes, subsidies, exchange rate valuations and other methods governments can create economic environments which incentives farmers to display particular behavior. In addition to the policies directed at agriculture, other government actions can create an economic climate that may or may not promote a farmers use of conservation methods. Anne Krueger of the World Bank notes this possibility in her report “The Political Economy of Agricultural Pricing Policy”. In her report Krueger states that, “a country’s general economic policies may have far greater indirect effect on agricultural incentives than its agriculture-specific or direct pricing policies do.” Krueger uses Ghana as an example where, “the most important influence on all agricultural prices was macroeconomic policy related to inflation and a highly overvalued exchange rate.” (Krueger, 1991).

Krueger’s analysis indicates that the fiscal incentives farmers have to implement soil conservation technologies are a function of broader economic themes within a country such as is desire to create heavy industry or import consumer goods. It is this complex relationship between the economic conditions within a nation and the quality of its agricultural lands that this research seeks to explore. Identifying what political agendas and economic conditions create patterns of land degradation is the first step in understanding whether land degradation is the result of geography or policy. In an effort to quantitatively analyze the relationship between agricultural land quality and a nations economic climate proxy measures for a nations economic climate must be used. A nations status as a net food exporter or importer is one possible proxy measure. Being a food exporting nation indicates that the agricultural land within a nation maybe being used for the short term profits of exterior nations thereby limiting the amount of revenue that flows back to the farmer for investment in soil conserving technologies. Alternatively if a nation is a food importer it may indicate a lack of investment in the land quality creating a scenario where the land cannot yield adequate food. The amount of food aid a country receives is also a possible proxy for the economic conditions within a nation. Receiving high amounts of food aid may indicate that land quality has deteriorated to an extent that it cannot support the population. Finally receiving a structural adjustment package from the International Monetary Fund or World bank may also be an appropriate proxy, the adjustment package seek to recreate domestic economies in a free market manner that can significantly change the economic incentives farmers receive. Using these proxy measurements this research hopes to provide quantitative insight into the relationship between economics conditions and land quality.

Methods

In order to address the research questions posited previously and further explore the relationship between political economic factors and land degradation in Sub-Saharan

Africa a GIS, excel, and SPSS Statistics based methodology will be implemented. Using these tools in conjunction with; land degradation data from the World Map of the Status of Human Induced Soil Degradation generated by L.R. Oldeman et al. in association with the United Nations Environment Programme, political boundary data from the GeoCommunity website, as well as Food and Agricultural Organization (FAO) data concerning agricultural trade and food aid deliveries I hope to capture complexities and relationships embedded in the agronomic land degradation dilemma.

To begin The World map of the Status of Human Induced Soil Degradation is downloaded from an online server located at http://www.isric.org. The map is the result of a worldwide survey of regional soil science experts conducted from 1987-1990. Each regional expert evaluates on a scale of 0-4 (0 being the least and 4 being the most) how severe human induced soil degradation is within his or her region. The results were then compiled by Oldeman and mosaicked onto one map available for public download. This map can be opened using ESRI GIS ARCmap software and saved as a shape file to the Lewis & Clark College GIS server. Then using ARCcatalogue and the *Define Projection* tool under Data Management Tools in the ARCtoolbox the map can be given a spatial projection. For this research the data was projected using the Mercator spheroid projection because that was the projection used by the political boundary data. The political boundary data can be downloaded from www.geocomm.com. Once both the GIS datasets have been downloaded and saved as shapefiles the data manipulation can begin.

To begin those states involved in the research, i.e. those states in Sub-Saharan Africa are selected one at a time from the attributes table of the political boundary layer. For this research all sub-Saharan African states were selected excluding those that incorporated parcels of the Sahara desert and small island nations. Nations that contain parcels of the Sahara desert were excluded because of the area normalization that occurs later in the methodology, and small island states were excluded because the land degradation data is not fine enough to differentiate parcels on the islands and because the political economic conditions of small island nations is significantly different from continental nations or large islands such as Madagascar. A total of 36 nations were selected for the research, they are: Gambia, Liberia, Ivory Coast, Burkina Faso, Ghana, Togo, Benin, Central African Republic, Botswana, Zambia, Zimbabwe, Burundi, Rwanda, Uganda, Swaziland, Malawi, Djibouti, Madagascar, South Africa, Senegal, Guinea-Bissau, Guinea, Sierra Leone, Nigeria, Gabon, Equatorial Guinea, Cameroon, Congo, The Democratic Republic of the Congo, Mozambique, Tanzania, Somalia, Kenya, Namibia, Angola, and Lesotho (Note: Ethiopia was excluded due to a lack of available data from the FAO).

These nations were selected individually from the political boundary layer, where the *create layer from selected features* tool was used to create a polygon layer for each individual country. Then using the clip tool with the land degradation layer as the input feature and an individual countries polygon as the clip feature, a new layer was created for each nation. This layer is the shape of a particular nation and is composed of smaller polygons that represent the severity of degradation via values 0-4 with 0 being no degradation and 4 being the most severe in various regions of the country, this data is projected in figure 1. Once these polygons reflecting the regional severity of land degradation have been created for each country the spatial data can be extracted from them.

To extract the spatial data from the country specific degradation severity layer, the *select by attributes* tool was used. By selecting the degradation severity layer of a given nation and entering “severity” = 0 for example the all the polygons in within the nations boundaries with a land degradation severity of 0 would be selected. This select data would then be exported as an excel file. Using the *select by attributes* tool each class of degradation severity in each nation was exported to excel for analysis. As a result of the clip function carried out previously, the small severity polygons that make up each national area were given an additional field in the attribute table labeled *shape area*. Each small polygon has its own shape area which can be considered a portion of the area of the nation, the sum of the *shape areas* of the severity polygons would be equal to the shape area of the entire nation. In excel the total shape areas for each class of severity were added such that a cumulative area of severities 1 -4 was known for each nation.

In addition, the land degradation data has a field for the cause of the degradation, agriculture and grazing activities were both included as possible causes so another sum of data was create that reflects the area of degraded land specifically by agricultural and grazing causes. Once the sums of individual categories of degradation severity are calculated they can then be added together to get the complete shape area of the nation. Once the shape area of the nation is calculated it can then be used to calculate the percent of land in each nation of degradation severities 0-4. Knowing the percent of the total land in each nation that suffers from a specific degree of land degradation allows a weighted average land degradation to be calculated for each nation. To calculate the weighted average the percent (in decimal form) of land of severity 0 for example is multiplies by its severity so the formula is as follows: (%0)0+(%1)1+(%2)2+(%3)3+(%4)4). The result would be a composite value for each nation. This process was carried out for the entirety of degraded land in the nation as well as for degradation associated with agriculture and grazing specifically and can be viewed in table 1. The graphical distribution of each nation's composite degradation values are projected in figures 2 and 3.

Having generated a weighted average of land degradation severity in each nation. Next comes accumulating the data with which to compare it. The Food and Agricultural Organization has archived a significant amount of data concerning many elements of agricultural practice, these data are available at the database FAOstat. For this research agricultural trade data and food aid data were used. The database aggregated agricultural imports and exports as well as food aid shipments by year. The land degradation data was finalized in the year 1990 so that is the most recent year data could be drawn from. For each nation the food exports, imports, and food aid shipment received for years 1961-1990 were downloaded into excel. For each year food imports were subtracted from exports, and the data viewed in a scatter plot. Using the scatter plots it was decided that a fifteen-year time lag would be used from 1990 to evaluate the role of exports and imports. This fifteen-year lag was in some way arbitrary, but is an attempt to capture the time lag it takes for consequences of land use practices to manifest themselves in measurable changes in the land. Having established this time window the average exports from 1975-1990 were calculated. In order to normalize the export data for comparison the average fifteen-year exports were divided by the area (in square kilometers) of each nation. In addition to calculating the average exports over the fifteen-year period the standard deviation of those exports was calculated in order to evaluate the role changes in agricultural production might have on degradation severity. Total food aid in tons was also calculated and normalized similarly to exports using the area of the nation in square kilometers. The final independent variable that was examined was the implementation of a structural adjustment program before 1990, this data was more difficult to find than at first intended but Google and Wikipedia proved adequate to answer this question.

Table 2 displays the results of this data archiving. With all the data in place a SPSS statics analysis was used to examine the relationship between land degradation severity, food exports/imports, food aid, and structural adjustment programs. A simple bivariate correlation was used to determine whether any of the independent variables vary instep with variance in land degradation severity. Bivariate correlations were preformed with weighted average land degradation and weighted average land degradation caused by agricultural and grazing as the two possible dependent variables with exports, stand deviation of exports, total food aid, and recipient of structural adjustment as independent variables. While exports were used in the form they appear in Table 1 with importing countries having negative values, another calculation took the absolute value of imports an exports to examine if have extreme dependence on exports or imports caused more or less degradation than a balanced middle of the road approach. The results of this analysis are viewable in figures 4-13.

Results

The results of this GIS based examination of political economic factors influence on spatial patterns of land degradation are statistically weak however, they do provide valuable insight for this research and others into the complex relationships embedded in socio-ecological systems such as agriculture. Those countries with the highest weighted average land degradation severity are: Togo(2.53), South Africa(2.54), Burkina

Faso(2.76), Madagascar(2.76), Burundi(2.94), Rwanda(3.14), and Lesotho(3.24). Those countries with the lowest weighted average land degradation severity are: Malawi(0.96), Democratic Republic of Congo(0.91), Angola(0.82), Liberia(0.76), Central African Republic(0.64), Gabon(0.4), Congo(0.37), and Equatorial Guinea(.23). When controlling for degradation caused only by agriculture and grazing those countries the most severe degradation are: South Africa(2.51), Togo (2.53), Burundi(2.51), Rwanda(3.14), and Lesotho(3.24). Likewise when controlling for degradation caused by agriculture and grazing lowest degradation was experienced by: Congo(0), Angola(0.05), Equatorial Guinea(0.056), Gabon(.057), Central African Republic(0.13), Ivory Coast(0.27), Liberia(0.32), Gambia(0.29), and Guinea(0.36). While the differences in these two datasets may appear significant here, the existence of a 0 value for Congo suggests that either the Congolese are the perfect agricultural land managers or that the methodology of Oldeman et al. is in some way flawed. I believe the latter and will discuss it in greater depth in the next section.

Table 3 displays the results of the bivariate statistical analysis performed during this research. This analysis shows that statistically speaking there was no significant difference between the land degradation severity average that is specific to agriculture and grazing and the average that is more general. There is little to no correlation between fifteen-year average exports and average land degradation. Being a recipient of a structural adjustment program also has little significant relationship to degradation severity. However, standard deviation of 15year exports, food aid received, and the absolute value of imports and exports all have interesting results. The only statistically significant relationship is between food aid and average degradation severity with a

Pearson correlation of .378, however it is impossible to know whether the food aid was in response to the poor land quality or a contributing factor to the deterioration of the land quality. The remaining variables, standard deviation and absolute values of import and exports, have moderately high Person correlations around the .3 range. It is these two variables that offer the most insight into the relationship between land degradation and socioeconomic practices.

Although the data concerning standard deviation and absolute value of exports/imports do not fully meet the criteria for statistical significance I find them significant because I feel nuances in the data may explain for the error. In the case of the absolute value of Export/Imports the analysis shows a moderately positive correlation between higher amounts of exports/imports in agricultural goods and higher amounts of land degradation. This relationship might be stronger if not for the fact that by averaging the past 15 years of exports a nation that experiences of high exports in years and high imports in other years will have a similar average to a nation that maintains a relatively equal balance through out the year. It is possible that those nations that have drastically fluctuating trade balance may experience more degradation that those that remain steady, and a methodology that can appropriately differentiate the two may have better answers.

The standard deviation argument is similar to the absolute value argument. The standard deviation of exports was used in order to attempt to capture the role changing agricultural practices can have on land degradation. However these changes can take various forms. Some changes could be like the absolute value argument where nation switch between importing and exporting, other changes could be steady or drastic increase in exports or imports. The moderately positive correlation between standard deviation of exports and land degradation suggest that larger changes in production systems may be detrimental to the land, but again a methodology designed specifically to examine the ways these changes can effect land quality is required for a fuller understanding.

Although GIS based methodology performed during this research did not yield correlations between exports, food aid, or structural adjustment and the spatial distribution of land degradation, the act of preforming the analysis illuminated disparities in time, space, and complexity that make a strictly quantitative analysis difficult, especially at the regional level. By identifying these disparities I hope to provide a framework that can be used to design future research projects focusing on questions that unite quantitative features of an environmental phenomena with the more qualitative features of socioeconomic conditions.

Time

Beginning with time, the World Map of Human Induced Soil Degradation though useful is limited in its descriptive and explanatory capacity because it represents a single point in time. The map was finalized in 1990 after three years of data accumulation. The data for each region of the map was submitted by local experts and then compiled and mapped by Oldeman et al. Although there are definite merits to this approach such as the 'situatedness' of each expert, there are also serious drawbacks. The most significant of these is that the map does not have any ability to show change through time. While the map portrays experts' estimation of the human induced soil degradation there is no official starting point in time or land quality that can be used to orient the data in time. Likewise it is unclear if the degraded land has remained degraded or been improved since the reports were collected. The lack of ability to display change makes it difficult to associate social systems with changes in natural phenomena because it is impossible to tell whether the social system changed the natural environment or the conditions of the natural environment forced a change in social system. Only by having a map that shows change through time can these difficulties be reconciled.

Equally as important as the lack of time sensitivity in the land degradation data is the existence of time lags between social and ecological systems. Agricultural lands are situated at the nexus of these two disparate systems. On one hand long-term geomorphic process are eroding and reshaping the land in conjunction with chemical changes in the soil. On the other side governments, corporations, and individual farmers interact directly or indirectly with the land to bend it to their will. These human actors and institutions act on far shorter timescales than the land itself does, therefor when a change occurs either in the land or the social system that the land is a part of, there are unknown and perhaps incalculable time lags that mask the effects of these changes into the unknown future. In Sub-Saharan Africa these time lags have been significant because of the prevalence of conflict, regime change, and international insertion in domestic politics and economies. This great array of change that occurs in a short amount of time (geologically speaking) makes associating any one social system or practice with patterns of degradation very difficult.

Space

When using GIS software in an analysis space obviously plays a critical role in the research. In the case of this research space was used to broadly to provide adequately specific answers. The first problem that this methodology has concerning space is again concerned with the land degradation data from Oldeman et al. The data was generated from field experts in different regions compiling data and sending it in a report to Oldeman where he then compiled a map from the data. This means that for each area on the map, the methodology of data collection and interpretation was at best slightly different. This problem manifests itself most readily in the 'cause' field of the land degradation data. In some cases the field was very specific with primary and secondary causes for the land degradation noted. In other cases no cause was given or the cause was said to be deforestation, while the cause for the deforestation was unknown. The result of these discrepancies in the data make it difficult to know what caused the land degradation or if it was even degradation. Urbanization perfectly illustrates this problem. Urbanization is not a option for the causes of land degradation the only options are: Deforestation, Overgrazing, Agricultural, Overexploitation of vegetation for domestic use, and (Bio)industrial activities. With a classification system of this nature it is unclear how the implementation of modern infrastructure was treated in the methodology. While some of the experts may view asphalt as degrading the land others may view a road as developing the infrastructure of the area and not necessarily degrading the land.

A spatial flaw of my own creation is the normalization of export and food aid data by using the area of the nation. By normalizing agricultural exports/imports by the area of the country this assumes that agriculturally productive land is distributed evenly in nations, which is obviously not true. My assumption when normalizing for area was that smaller nations inherently have less land to use to produce goods or sustain people and therefor need to be placed on even ground with large nations. While normalizing by area alone detracted from the quality of the methodology, I do not think It renders the research unviable because as stated early I am attempting to create a framework to research these complex issues. In addition to creating an technical problem, the lack of information on the agricultural regions of individual nations made it difficult to select relevant independent variables. Because I was using the land degradation map of the entire nation, I had to use the trade data on all agricultural products rather than being able to look sector specifically at grain for example. The FAO offers data on each agricultural item traded which means that if sector specific data on agricultural activities becomes available it will be possible to look at the trade status with individual goods and the quality of the land they are produced on.

Complexity

Issues of complexity are perhaps the most difficult to reconcile when trying to associate socioeconomic conditions with ecological phenomena. Specifically isolating variables for research. Land degradation is a process accelerated by humans and agriculture. However, it does occur naturally, heavy rains increase erosion, periods of drought fail to replenish the soil nutrients needed to sustain cultivation, changes in the regional water table can drown or parch the soil. These processes are occurring every day at a slightly different rate all across the world. It is therefor extremely difficult to isolate a variable such as agricultural exports. For example in this research the exports over a 15-year period were averaged for each country and this data compared with land degradation values. What is critically missing in this analysis is the climatic condition in each nation, or each region of each nation. Without a way to input the climatic conditions into an analysis it is impossible to say whether the increased degradation is due to changes in human behavior and institution or a result of a climatic shift in the region that in moving resources away from a given region.

The final issue of complexity has to do with the use of experts. Previously in this section I frowned on the use of an expert report methodology when considering spatial elements. However, when looking at complexity a benefit to using experts appears in that they are situated within the complexity of the system they are reporting on. They are aware of the actors and processes relevant to land quality in their region. If an attempt were made to reproduce the World Map of Human Induced Soil Degradation using a set of measureable standard rather than experts a set of standard for land across the globe would have to be established and then monitored. The climatic complexity of land degradation makes a global standard of land quality difficult to establish, and even if a system were established the cost of implementing a monitoring system would be substantial.

Moving Forward

The above discussion may make it appear that it is impossible to reconcile the differences in time, space, and complexity created by analyzing ecological systems interaction with socioeconomic systems. However, I believe the research presented here has created viable options for research. The first necessity for this research would be a time sensitive data set on land degradation that can show change through time. Once that data is available it will be possible to compare patters of change rather than static indicators. The data concerning the standard deviation of export/imports is particularly relevant here. That data suggests that changes in agricultural practice may be significant contributors to land degradation. If a time sensitive dataset existed changes in the quality of land could be associated with changes in any number of socioeconomic indicators or systems. Most importantly a methodology based on analyzing change would have the possibility of observing and documenting time lags and their role in process of land degradation and agricultural production.

As population growth continues, particularly in sub Saharan Africa the demands placed on regional food systems will grow accordingly. In order to avoid the civil disorder, violence and environmental degradation that accompanies food shortages food production in the region will have to expand to meet this future demand. However, the sub Saharan region is home to some of the densest tropical forests and largest animals on earth. These places and creatures are surely to come into conflict with the demands and expanding food system will have. In order to preserve the natural beauty of the region and feed its populous the problem of agricultural land degradation in the region must be addressed, not in an esoteric sense, but with political and economic action in order to avoid the unfettered expansion of agricultural land. Reducing efficiency losses due to degradation will not only stabilize and increase the amount of food available to the populous; it will stabilize employment in the agricultural sector as well, which increases regional food security.

Controlling agricultural land degradation has positive implications beyond regional food security. The establishment of a strong and consistent agricultural sector can be instrumental in a nations development. In the 1950s the United States Department of Agriculture established soil loss tolerance values (T values) that dictate a maximum tolerable volume of soil erosion a farmers land could experience if he/she is to qualify for government subsidies (Montgomery, 2007). These tolerance values have allowed the central United States to produce surplus grain for the last half century while still maintaining high quality soil. While T values may not be the best road for each nation, each nation has a vested interest in the quality and efficiency of its agricultural production, mitigating soil degradation lies at the heart of agricultural practices. By establishing a methodology to properly understand the role political and economic decisions have on soil quality, hopefully governments in developing nations will be able to acquire the knowledge and tools to assert control over the vitality of their agricultural regions.

Figure 1: Severity of Human Induced Land Degradation in sub Saharan Africa Research Area

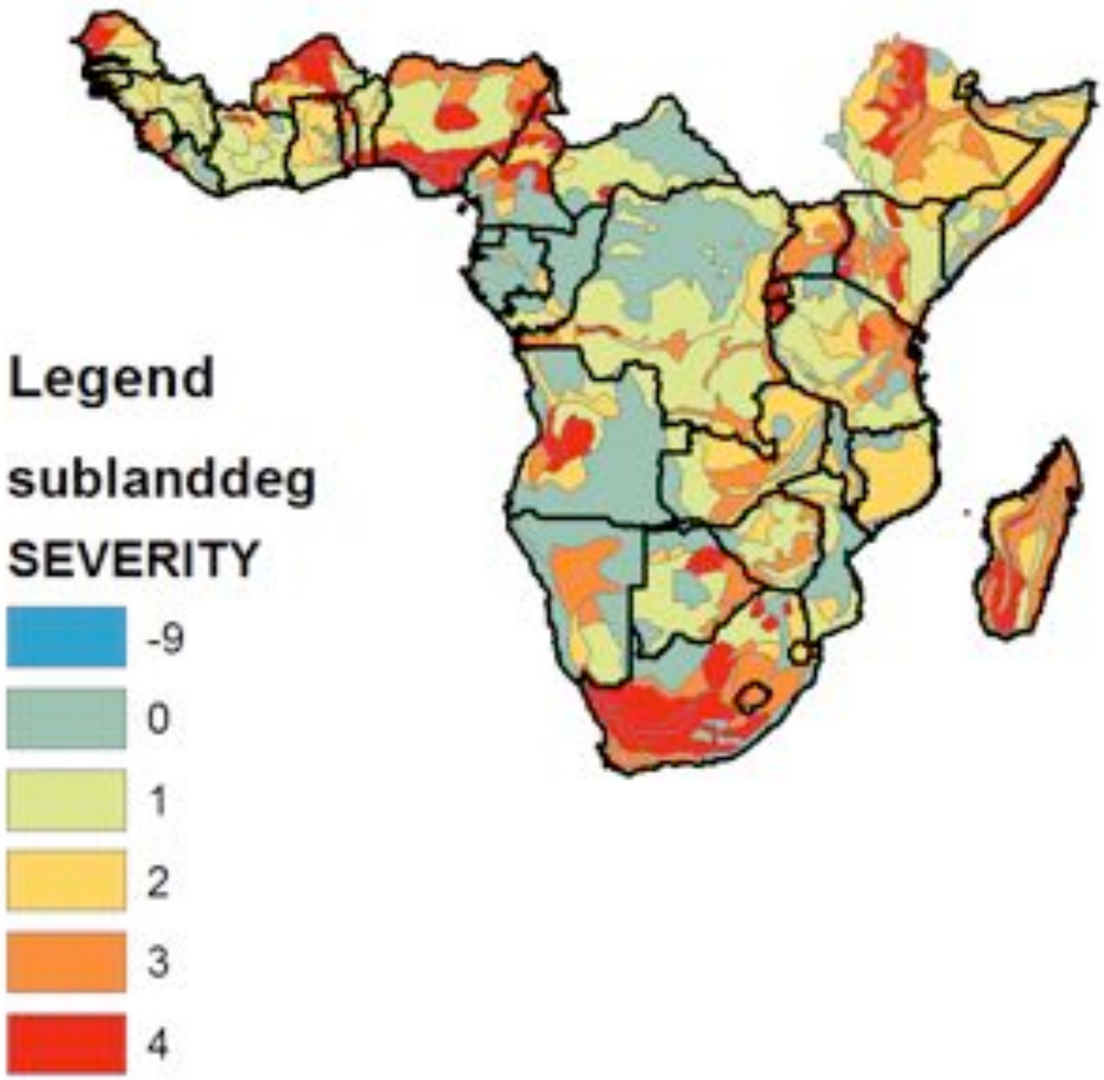


Table 1:Weighted Average Severity Calculations

Figure 2: Distribution of Weighted Average Degradation Severity

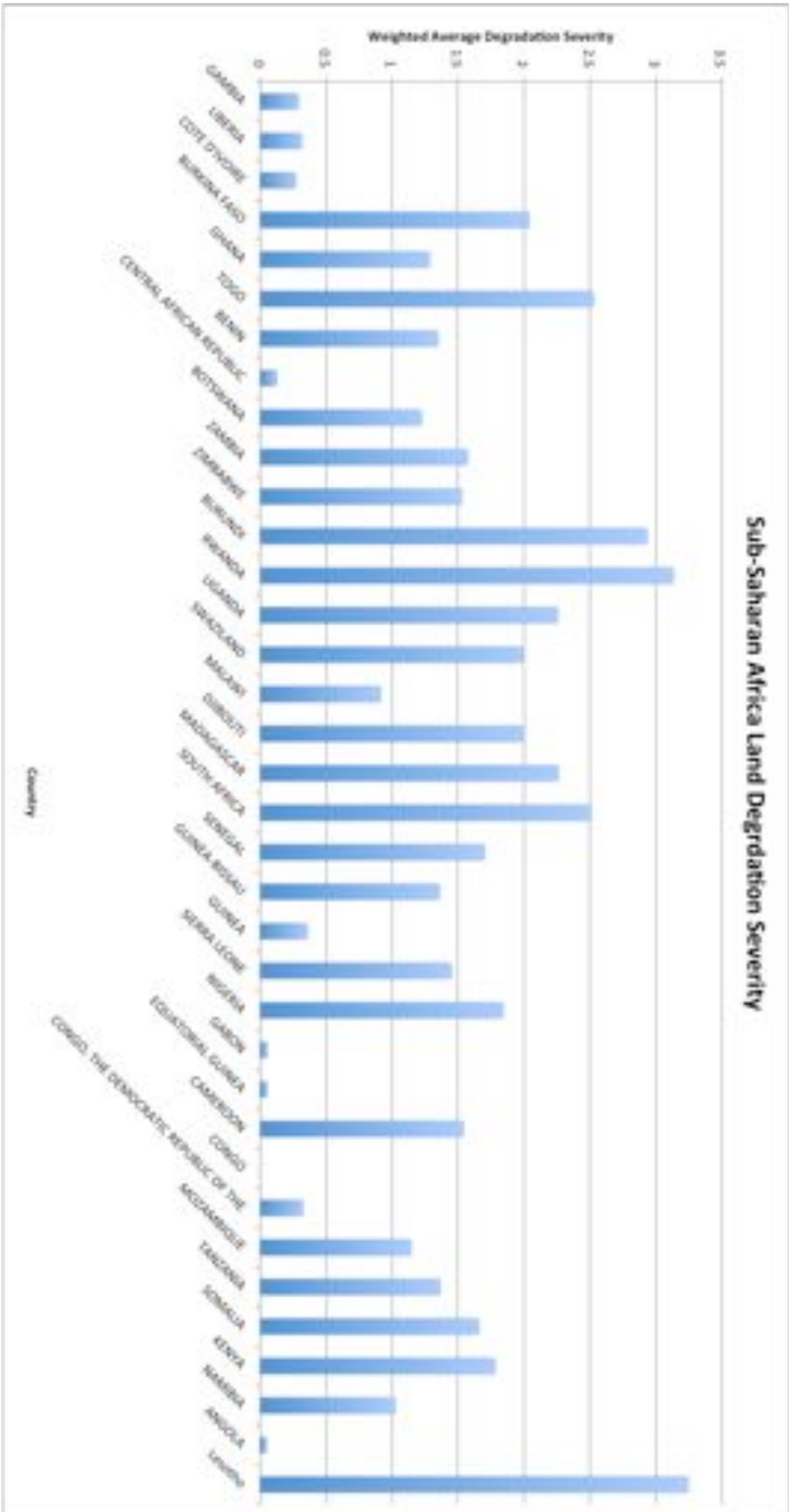


Figure 3: Weighted Average Degradation Severity Caused by Agriculture and Grazing

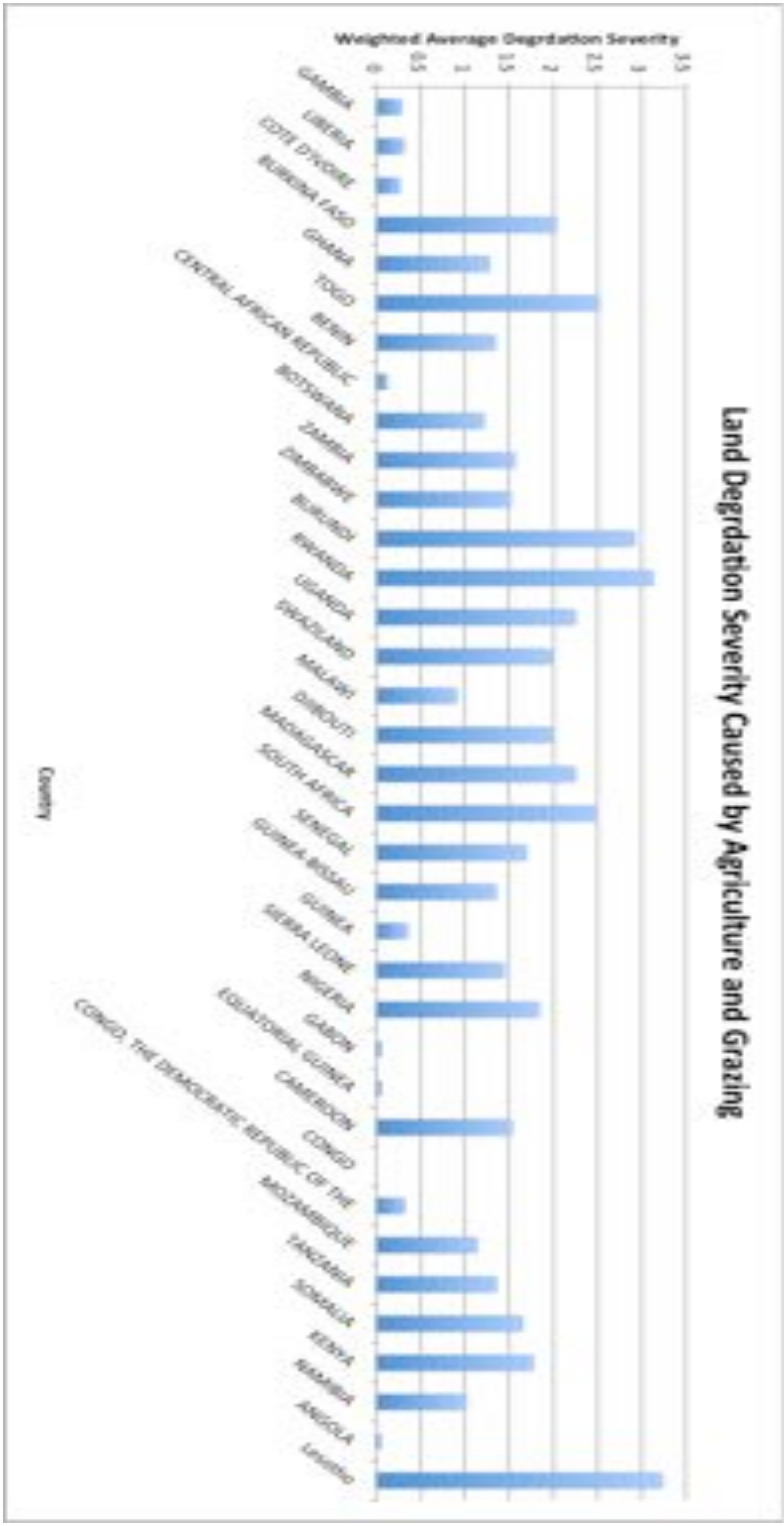


Figure 4: Degradation Severity and 15 year exports

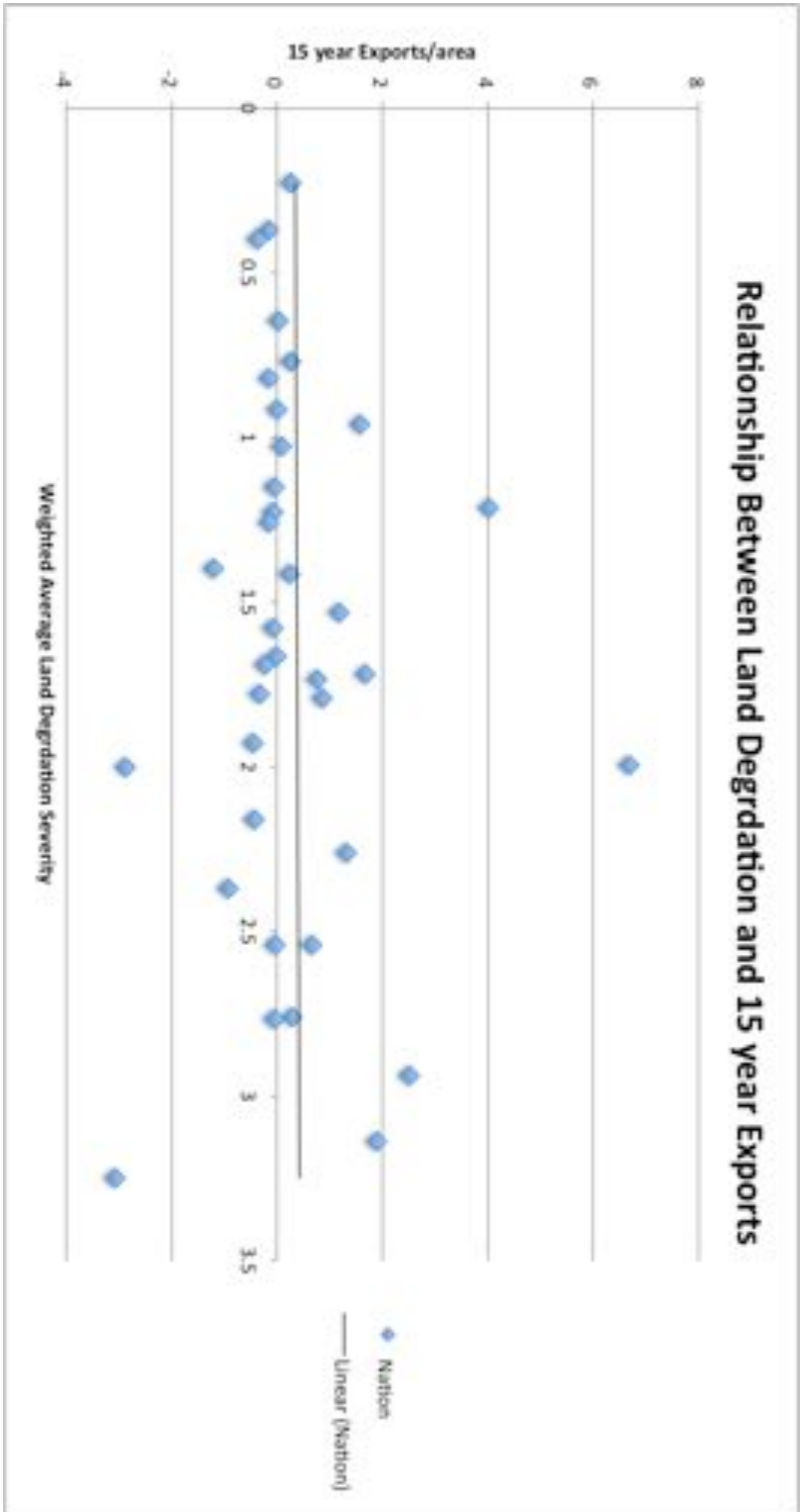


Figure 5: Degradation Severity and Standard Deviation of 15 year Exports

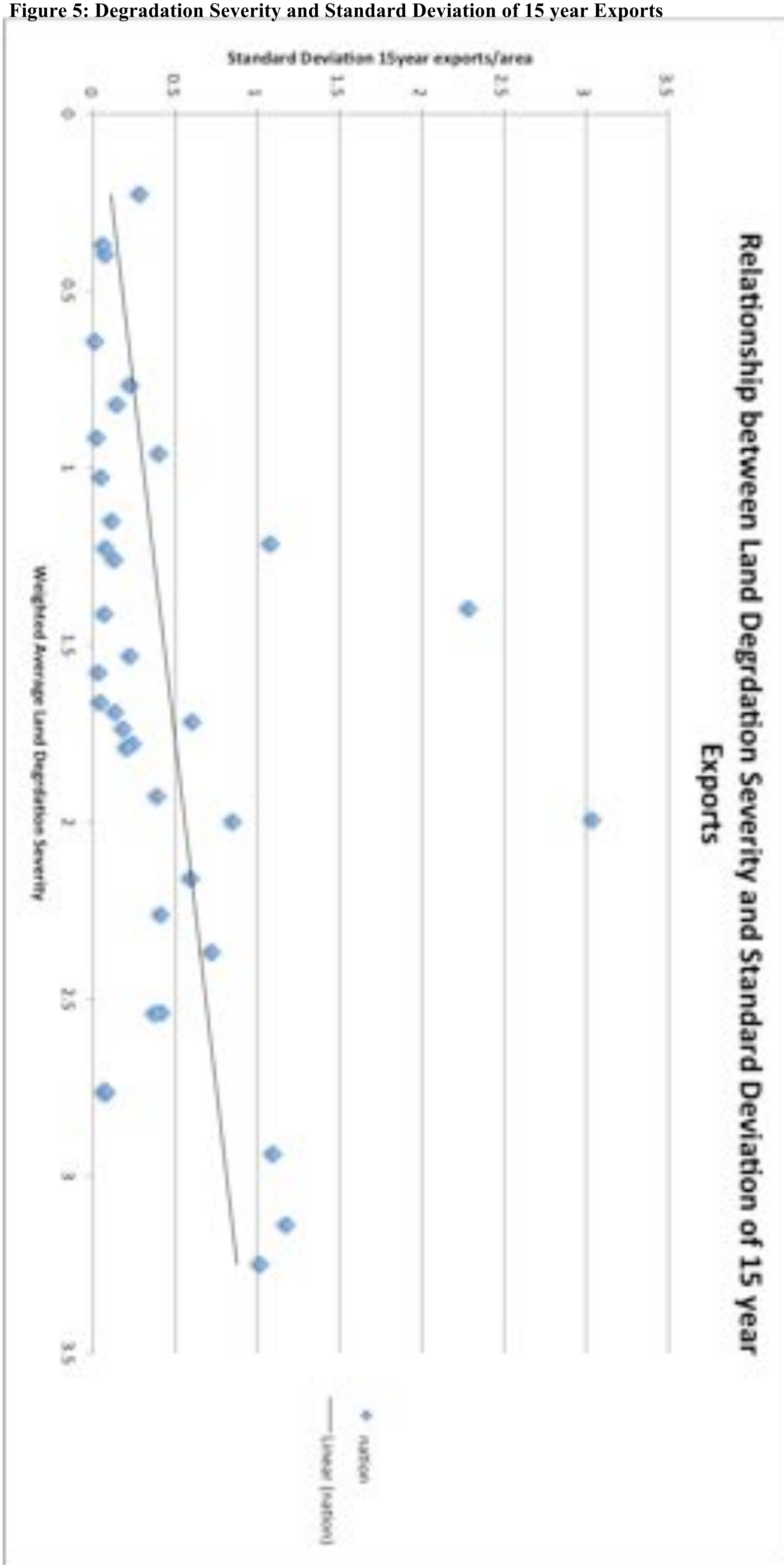


Figure 6: Degradation Severity and Food Aid Recieved

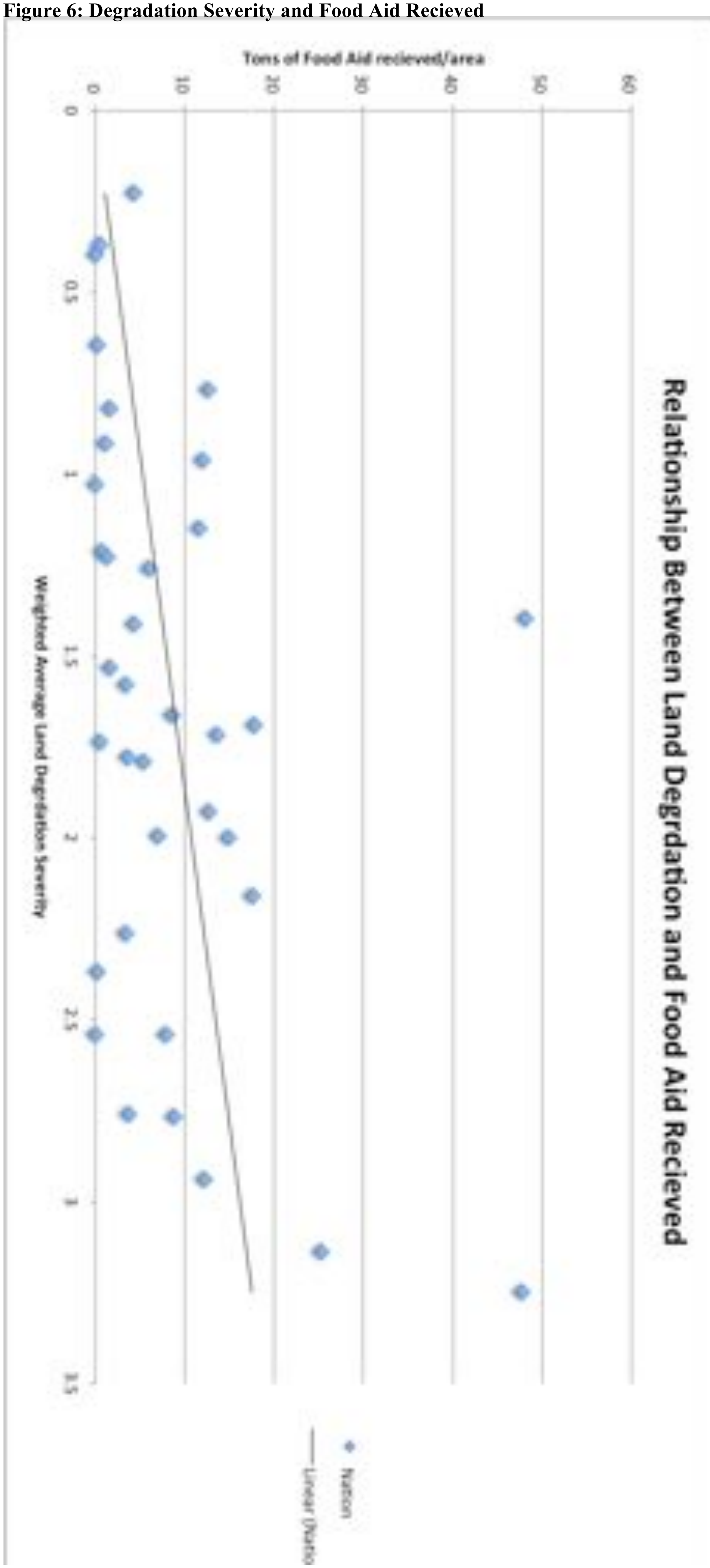


Figure 7: Degradation Severity and Structural Adjustment Recipients

Figure 8: Degradation Severity and Absolute Value of Exports/Imports

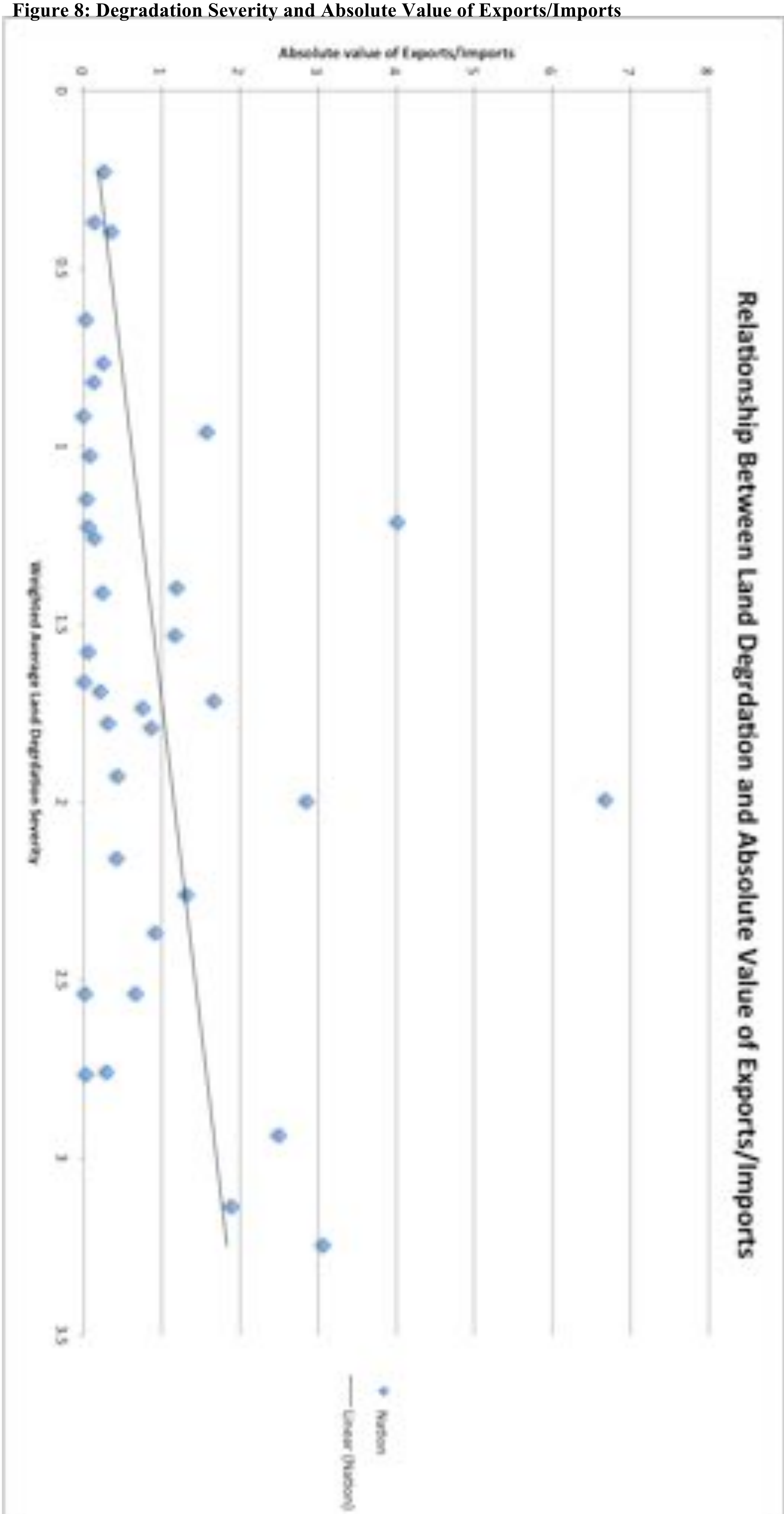


Figure 9: Agriculture and Grazing Caused Degradation and 15 Year Exports

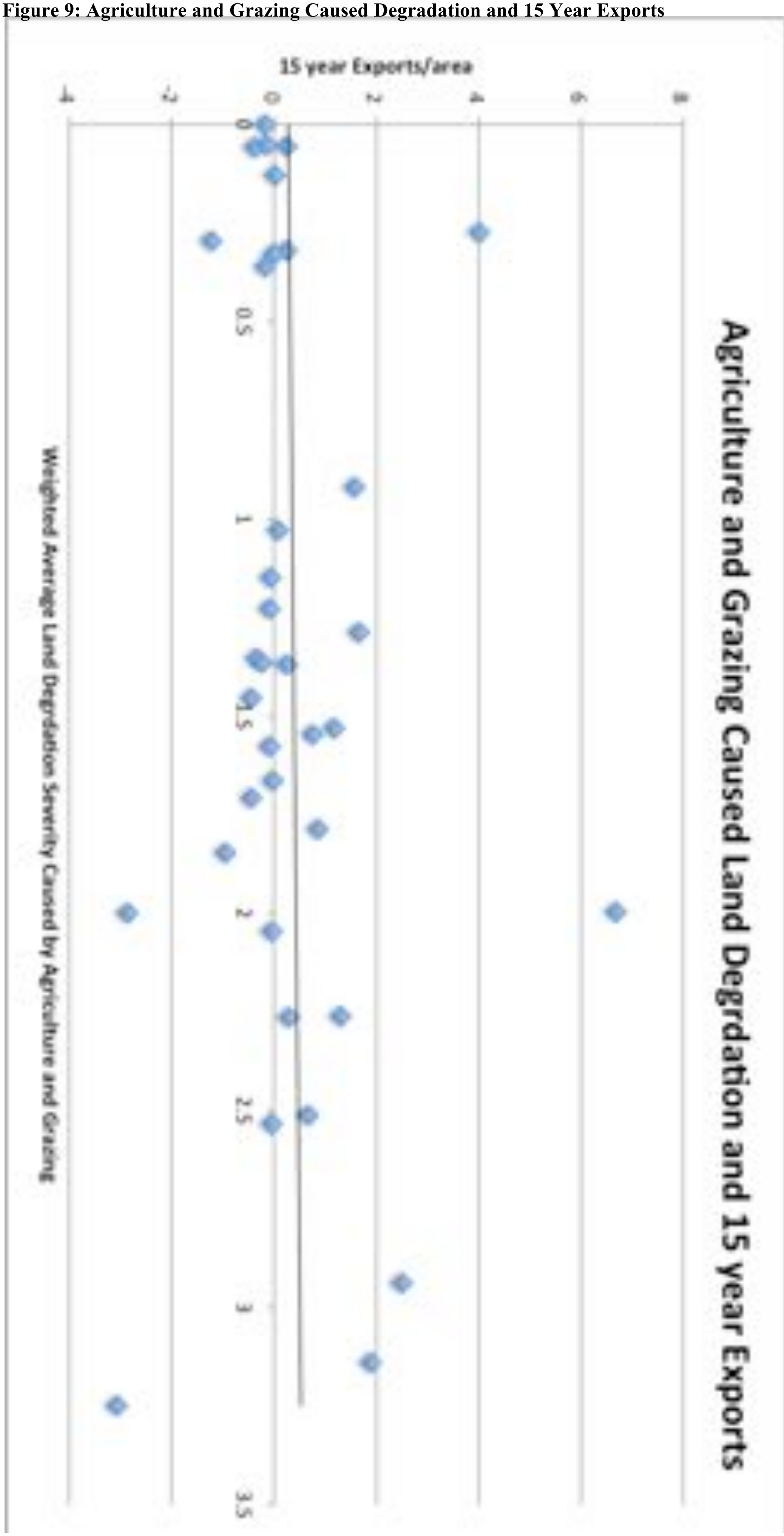
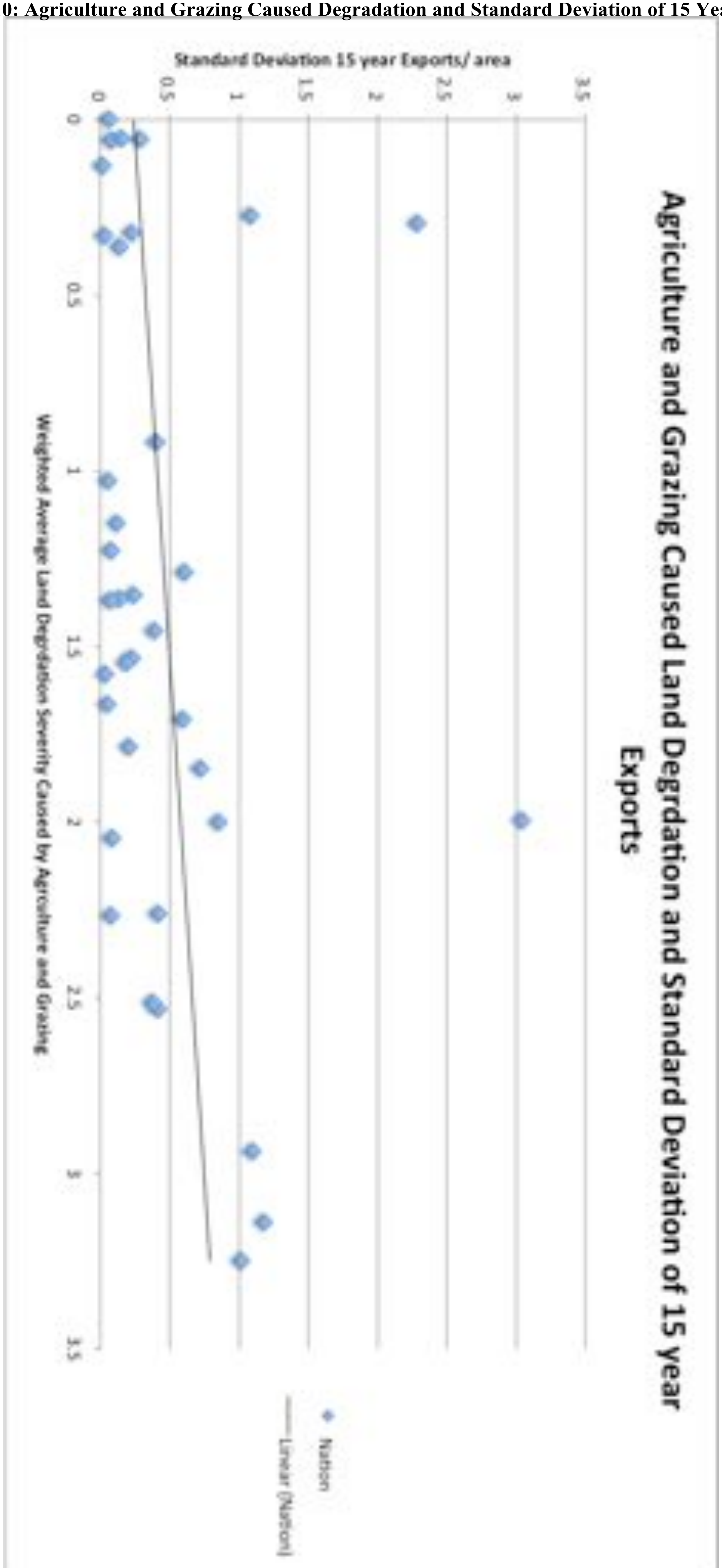


Figure 10: Agriculture and Grazing Caused Degradation and Standard Deviation of 15 Year Exports



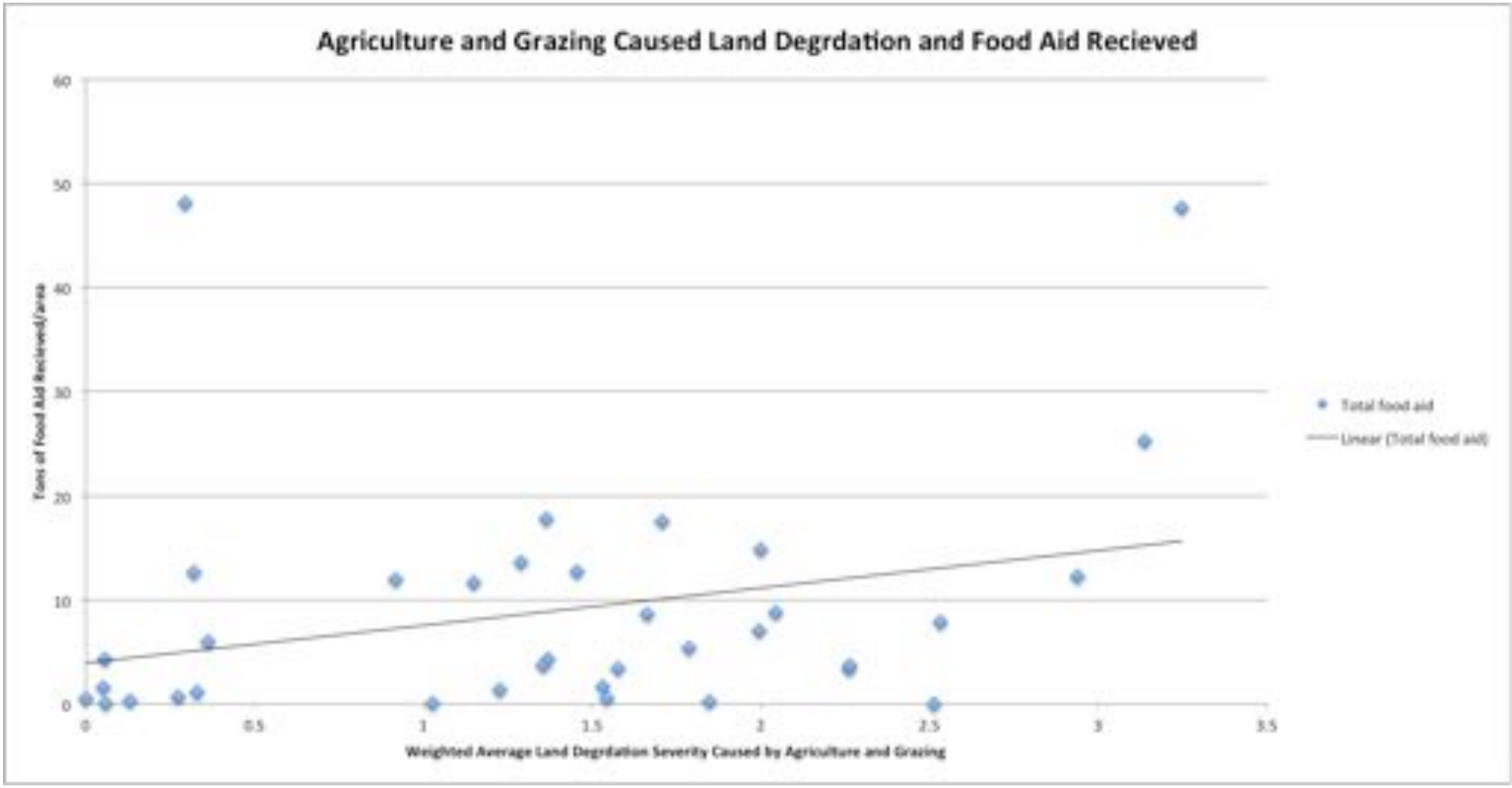

Agriculture and Grazing Caused Land Degrdation and Food Aid Recieved
Tons of Food Aid Recieved/area
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
Weighted Average Land Degrdation Severity Caused by Agriculture and Grazing
Total food aid
Linear (Total food aid)

Figure 12: Agriculture and Grazing Caused Degradation and Structural Adjustment Recipients

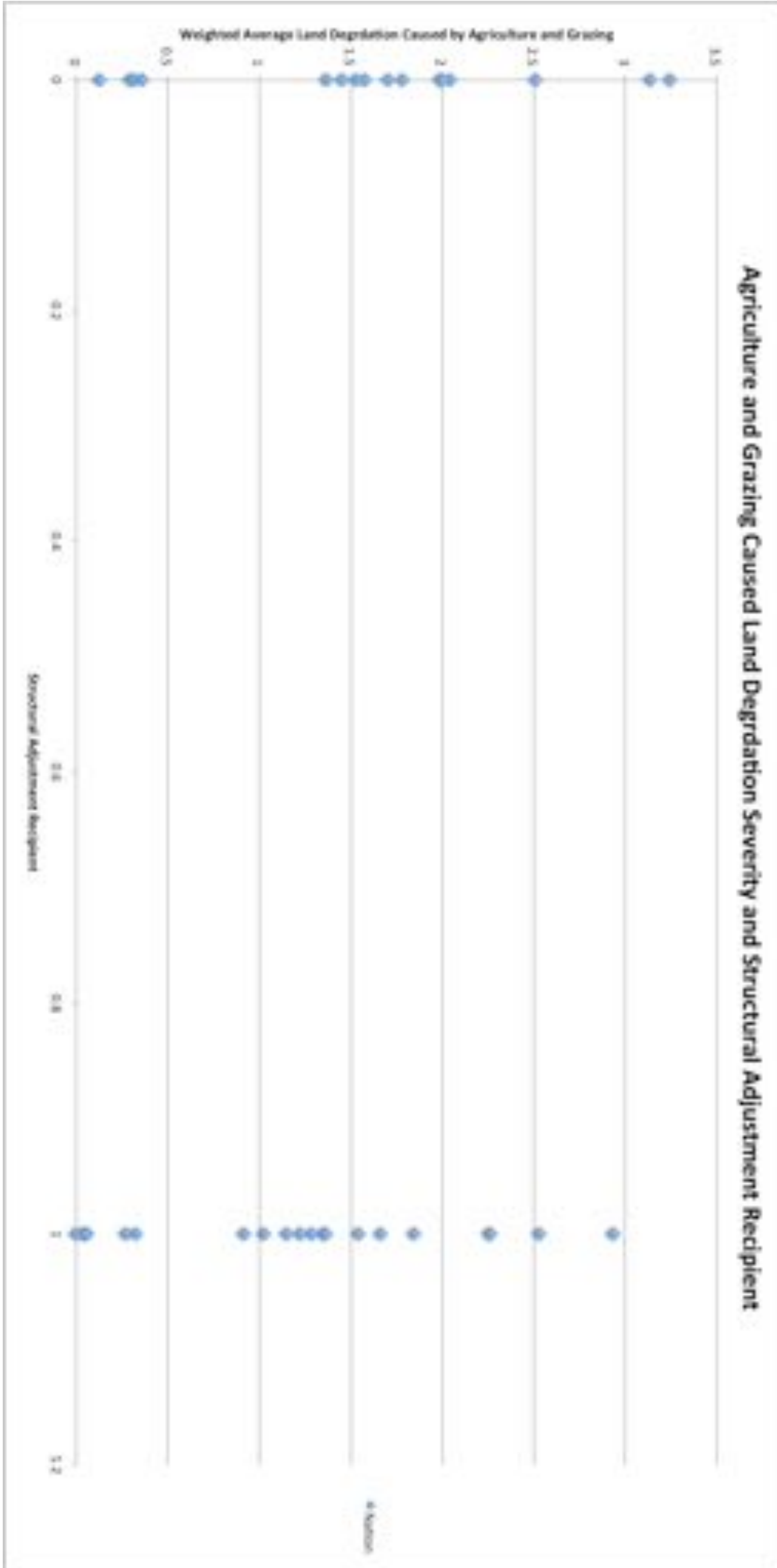


Figure 13: Agriculture and Grazing Caused Degradation and Absolute Value of Exports/Imports

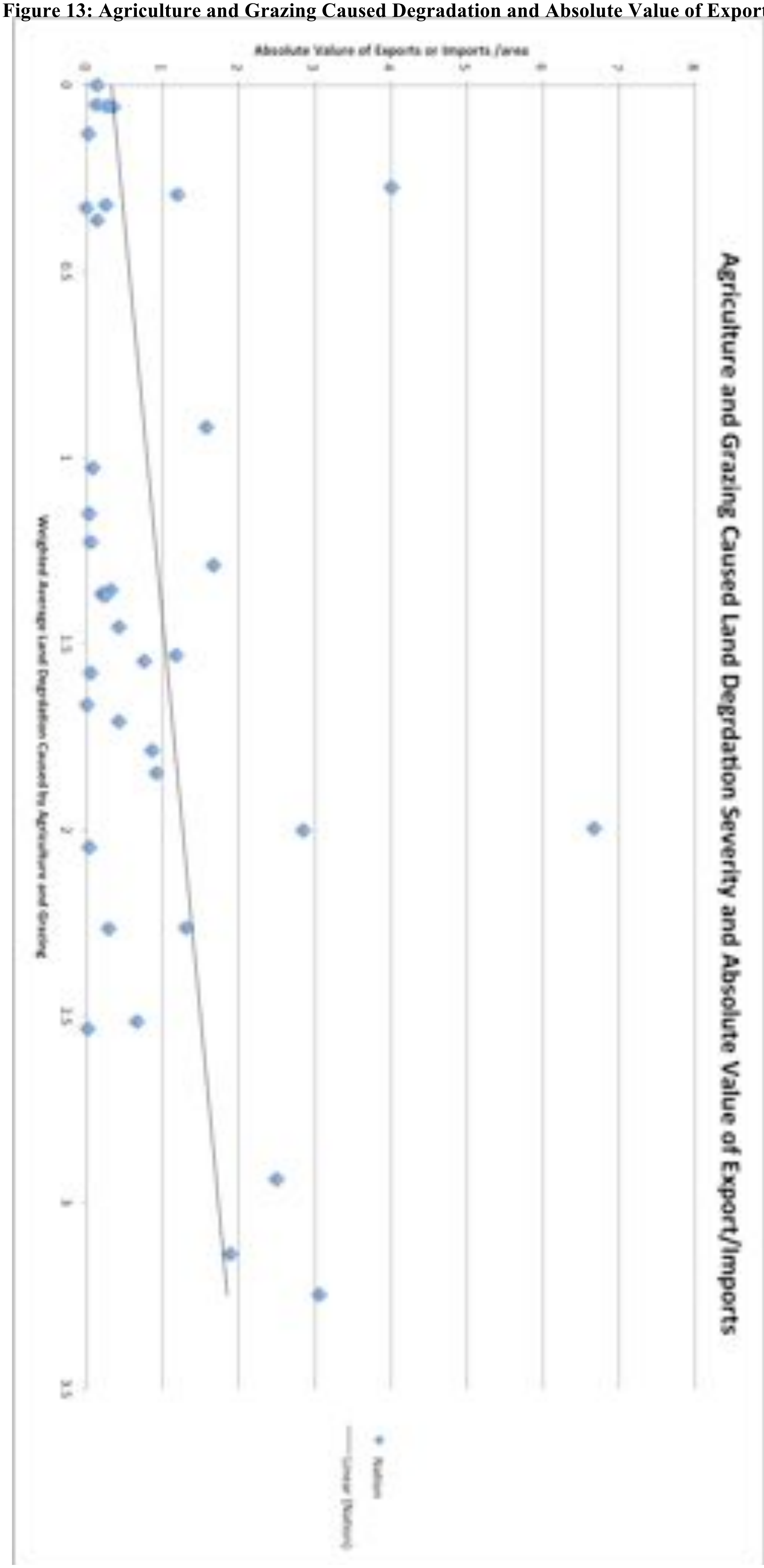


Table 2: Data Generate for Individual Countries in Research Group

Country	Area	Average Degradation Severity	Average Degradation Severity*ag	10yrExports/area	stdevofExports/area	Total food aid/area	Structural Adjustment		area km^2
GAMBIA	10603.4534	1.397851452	0.294025447	-1.201236004	2.2899588	48.12366128	1992	0	11027
LIBERIA	94214.99145	0.767575227	0.320661471	0.26315345	0.228954439	12.60842868 No		0	118790
COTE D'IVOIRE	326745.7556	1.213678136	0.276258208	4.026125558	1.083401158	0.692434396	1989	1	22625
BURKINA FASO	275761.9953	2.766169516	2.045228538	-0.042336275	0.083453834	8.78365895 no		0	240463
GHANA	241127.875	1.717633643	1.288839156	1.678258492	0.608709623	13.37364918	1984	1	327843
TOGO	58568.02402	2.539079212	2.532429076	-0.024151404	0.421667721	7.863796119 multiple?		1	46056
BENIN	120517.4102	1.779265528	1.354202408	-0.325884969	0.243876116	3.657471558	1989	1	64078
CENTRAL AFRICAN REPUBLIC	622098.0122	0.644069508	0.12987008	0.040162683	0.016904247	0.26157775 3	1998	0	16272
BOTSWANA	578743.1015	1.227105601	1.227105601	-0.06606407	0.079229174	1.347831184 No		1	78004
ZAMBIA	747294.2141	1.577812183	1.577812183	-0.065710565	0.037979341	3.363475794 1990s		0	251350
ZIMBABWE	386011.5058	1.531544977	1.531544977	1.184195107	0.230604173	1.636159584	1990	0	63246
BURUNDI	24836.97058	2.937935863	2.937935863	2.508417836	1.097018206	12.2307992	1986	1	30377
RWANDA	25348.88478	3.138370194	3.138370194	1.896044951	1.181620857	25.29192134	1990	0	64112
UGANDA	240680.3948	2.261845888	2.261845888	1.322879613	0.415220678	3.389345728	1987	1	81572
SWAZILAND	17914.81941	1.995321138	1.995321138	4.686356823	3.041787708	7.012685817 no		0	12543
MALAWI	125495.7476	0.960955754	0.918778538	1.583228944	0.405068586	11.94979136	1981	1	149964
DJIBOUTI	21570.31822	2	2	-2.858937308	0.851135801	14.85119491 no		0	32034
MADAGASCAR	590309.0444	2.75890071	2.264636033	0.299904773	0.079800989	3.664633015	1982	1	216327
SOUTH AFRICA	1212987.125	2.54016857	2.513013759	0.67180237	0.377700053	0.022178884 No		0	2700
SENEGAL	192109.841	2.160115393	1.707195883	-0.432647344	0.396208027	17.33849247	1994	0	106931
GUINEA-BISSAU	34604.3671	1.689574167	1.364620007	-0.219208782	0.140698126	17.73494228	1987	1	61373
GUINEA	247429.1523	1.259029792	0.361121024	-0.15336966	0.136145302	5.960227347 no		0	147475
SIERRA LEONE	71512.28081	1.927244236	1.454071824	-0.43972692	0.393132199	12.72483517 no		0	90998
NIGERIA	910614.3257	2.369012929	1.84736504	-0.930380138	0.727217042	0.1966277	1986	1	17905
GABON	269668.8765	0.397262298	0.057626742	-0.360242953	0.080448492	0.058419793	1988	1	1575
EQUATORIAL GUINEA	28413.33147	0.227470814	0.20645864	0.270414542	0.288524681	4.300025645	1988	1	12217
CAMEROON	478385.3476	1.735875636	1.345383778	0.764134826	0.189418753	0.344180319	1988	1	26032
CONGO	338339.1414	0.370151009	0	-0.153680675	0.064638966	0.344790339	1987	1	18432
CONGO, THE DEMOCRATIC REPUBLIC OF THE	2344648.828	0.91519157	0.328709697	0.008872917	0.029704275	1.231779052	1987	1	270989
MOZAMBIQUE	773082.3741	1.169809413	1.169756656	-0.048797181	0.120631249	11.62917609	1987	1	899046
TANZANIA	943295.4845	1.41230834	1.369916682	0.254216538	0.075846625	4.307774252 no?		0	406350
SOMALIA	637787.6956	1.663575876	1.663575876	-0.014196632	0.049519798	8.643907742	1980	1	551297
KENYA	593123.75	1.791194654	1.786321006	0.87568003	0.209518764	5.364802877	1997	0	318195
NAMIBIA	818406.0511	1.02775199	1.02775199	0.091805298	0.055351935	0.038180314	1988	1	3124
ANGOLA	1247521.087	0.820254439	0.052404789	-0.140270012	0.14960158	1.587632813	1988	1	198060
Lesotho	30540.46	3.248113503	3.248113503	-3.071092348	1.018234553	47.68460992 no		0	144677

Table 3: Results of Bivariate Analysis of Data

Correlations

		Exports_15yrs	Stdev_Exports_15yr	foodaid	Structural_adjustment_Recipient	Absolute Value Exports/Imports
Average_Degradation	Pearson Correlation	0.013	0.314	.378*	-0.252	0.31
	N	36	36	36	36	3
AG_cited_degrdation	Pearson Correlation	0.044	0.243	0.291	-0.21	0.311
	N	36	36	36	36	3

*. Correlation is significant at the 0.05 level (2-tailed).

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