

National Technical University of Ukraine “Kyiv Polytechnic Institute”  
Institute for Applied System Analysis

# Methods and models for sustainable development processes at international level

By Valentyna Sobko

Group KA-44m

Supervisor: prof. Petro Bidyuk

# Objective

**Goal:** to estimate and forecast values of sustainable development indicators, providing empirical evidence about the suitability of two different approaches: regression analysis and neural networks forecasting

**Object of study:** sustainable development indicators

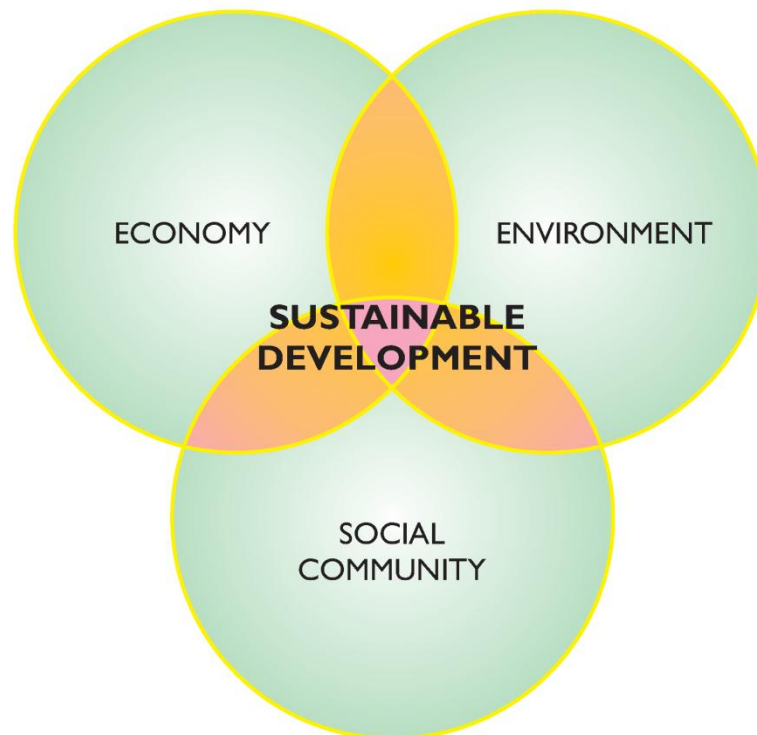
**Subject of study:** mathematical models and methods used to evaluate sustainable development

# Relevance of the study

- Brundtland Report (1987) and the Rio Conference (1992)
- The concept of sustainable development has been widely accepted and there has been recent progress in developing its measurement systems
- Much lower progress in the actual implementation of sustainable development measures and the integration of the three pillars (economic, social, environmental) remains problematic

# Domain of study

Sustainable development, as understood in the technical context, is currently defined as “balancing the fulfilment of human needs with the protection of the natural environment so that those needs can be met not only in the present, but in the indefinite future”



# HDI vs HSDI

## HDI

- **Wealth** is measured by Gross National Income per capita;
- **Health** is quantified by citizens' longevity (life expectancy at birth);
- **Education** is measured by composite of mean and expected years of schooling

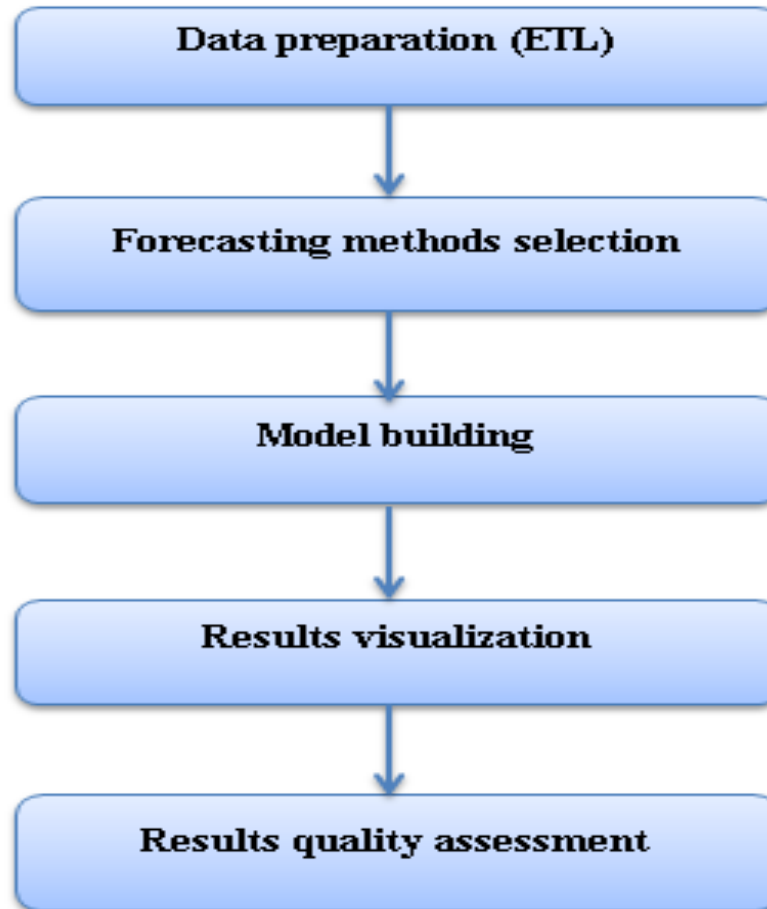
## HSDI

- Wealth
- Health
- Education
- **Environment** is measured by CO2 emission per capita

# Problem statement

- To collect necessary data regarding development of HSDI
- To construct mathematical models for short term forecasting of HSDI
- To compute six years forecasts of HSDI and compare the results achieved with different models

# Forecasting procedure



# Input data

- Life expectancy at birth (1961 – 2014), years: from The World Bank
- Education index (2005 – 2013): from The Human Development Report
- GNI per capita (1990 – 2014), 2011 prices international \$: from The World Bank
- CO2 emissions per capita (1960 – 2011), metric tons: from The World Bank
- HSDI (2010 – 2014): from The Human Development Report



# Regression analysis (EViews)

- **Multiple regression**

$$y_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_p x_{ip} + \varepsilon_i$$

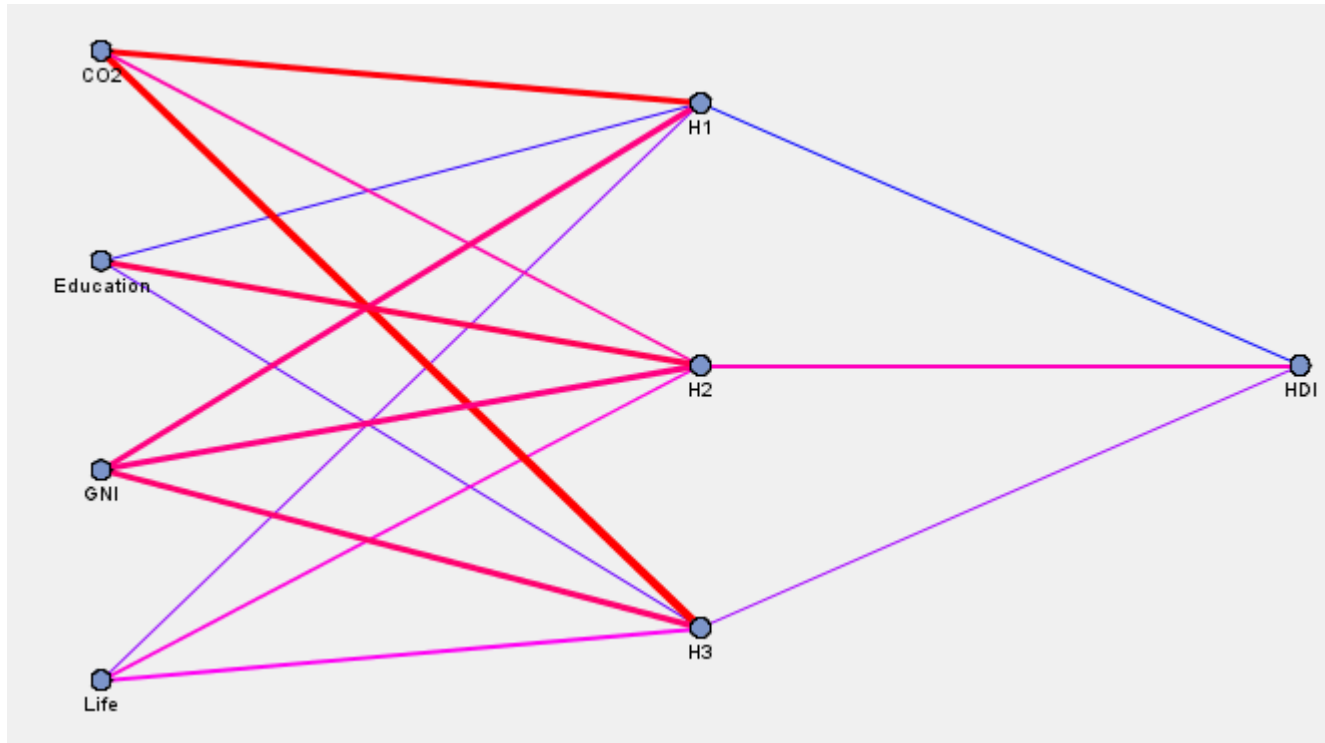
$x_{ij}$  is the  $i$ -th observation on the  $j$ -th independent variable

- **Autoregression AR(p)**

$$y_t = c + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + e_t$$

where  $c$  is a constant and  $e_t$  is white noise

# Neural networks (SAS)



A multilayer feed-forward network that has one hidden layer consisting of three neurons

# Results. Ukraine (1)

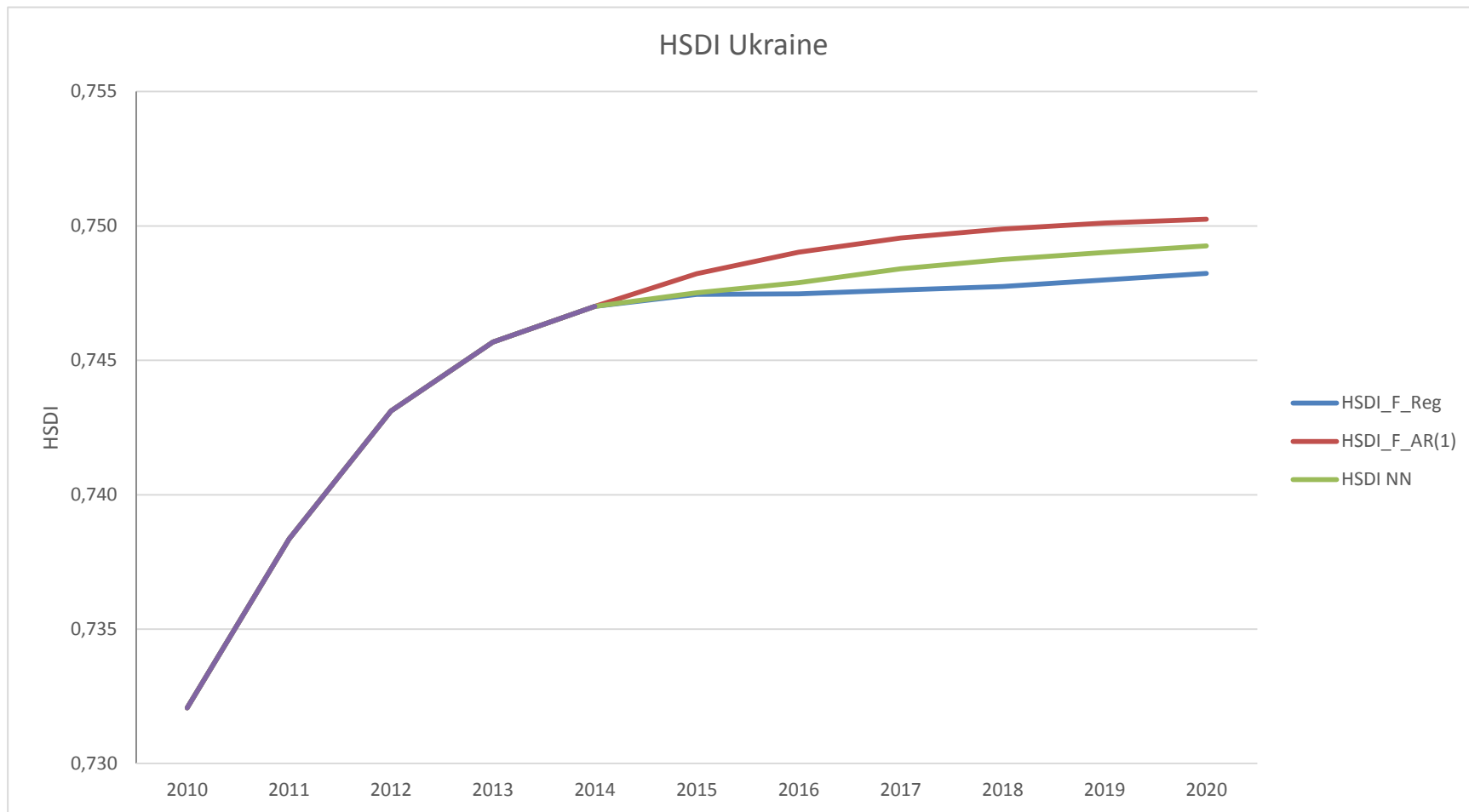
*HSDI\_F\_Reg(Ukraine)*

$$= -0,758243 + 0,020791 * LIFEF - 0,072041 * EDUF \\ - 1,57E - 07 * GNIF + 0,013010 * CO2F$$

$$HSDI_F_AR(1) = 0,750522 + 0,651885 * AR(1)$$

Model	R-square	DW	MAPE	MSE	Theil
HSDI_F_Reg	1,0	2,846678	7,32E-12	3,04E-25	4,96E-14
HSDI_F_AR(1)	0,977827	1,993443	0,053249	2,18E-07	0,000286
HSDI_NN	0,987877	2,678405	9,62E-10	5,92E-19	3,99E-19

# Results. Ukraine (2)



# Results. Norway (1)

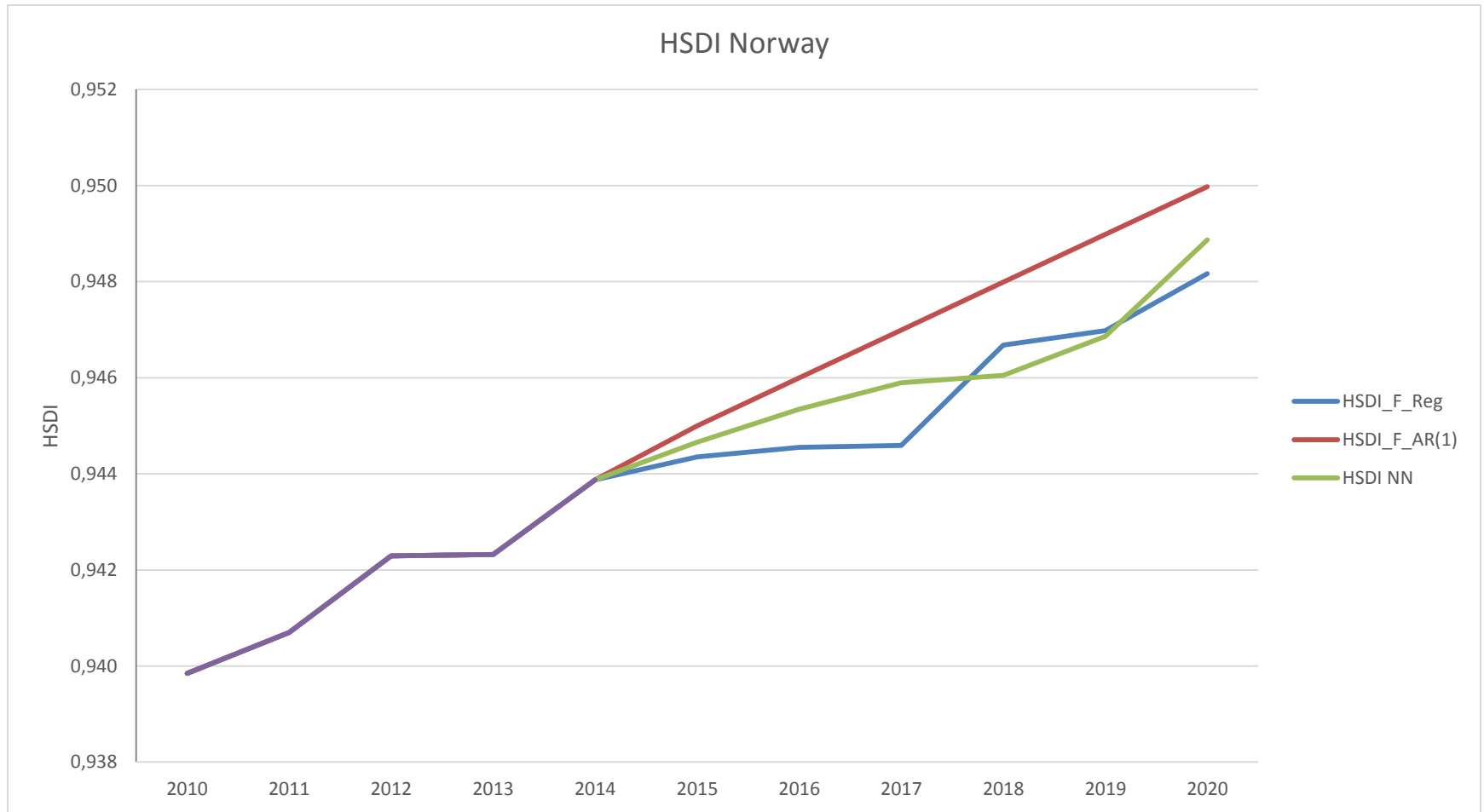
*HSDI\_F\_Reg(Norway)*

$$= 1,756411 - 0,004873 * LIFEF - 0,480238 * EDUF \\ + 3,30E - 07 * GNIF - 0,001311 * CO2F$$

$$HSDI\_F\_AR(1) = 2,335663 + 0,999283 * AR(1)$$

Model	R-square	DW	MAPE	MSE	Theil
HSDI_F_Reg	1,0	3,366461	4,92E-11	3,3E-25	3,05E-13
HSDI_F_AR(1)	0,578947	2,499282	0,026623	4E-07	0,000265
HSDI_NN	0,999795	2,50346	3,47E-10	2,7E-23	1,44E-23

# Results. Norway (2)



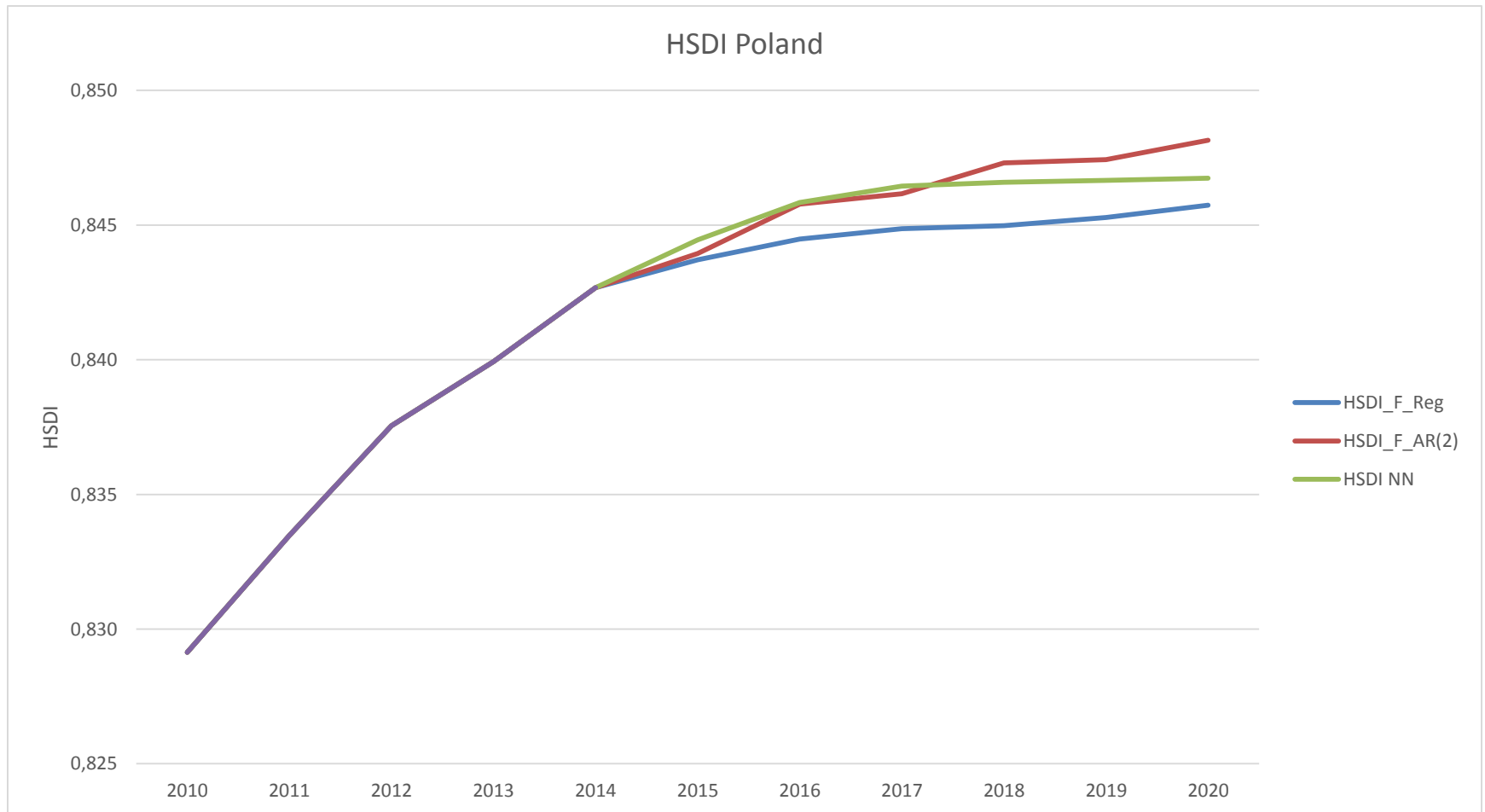
# Results. Poland (1)

$$HSDI\_F\_Reg(Poland) = -0,105691 + 0,040598 * LIFEF - 2,104058 * EDUF - 1,11E - 05 * GNIF - 0,036127 * CO2F$$

$$HSDI\_F\_AR(2) = 0,849125 - 0,117647 * AR(1) + 0,647059 * AR(2)$$

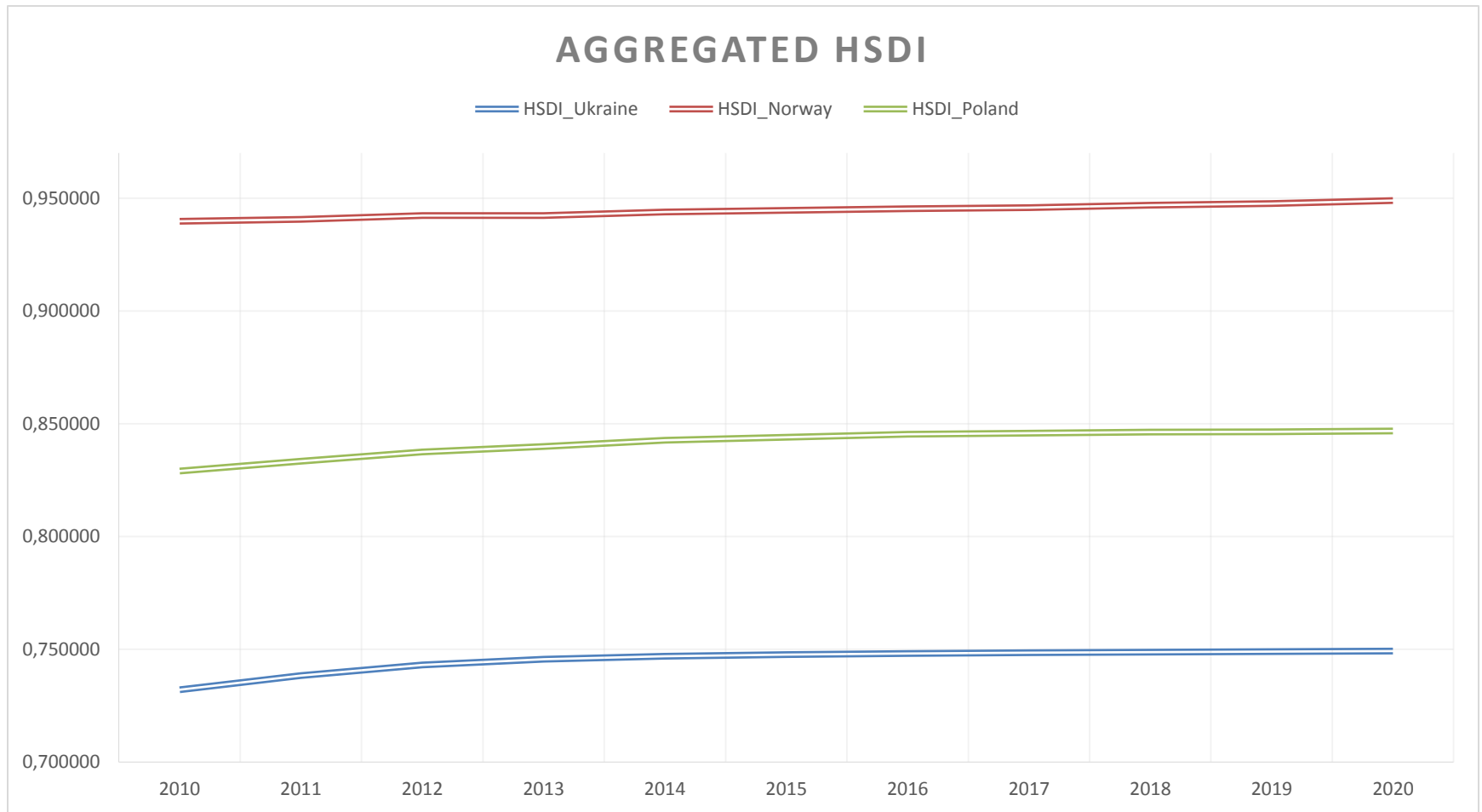
Model	R-square	DW	MAPE	MSE	Theil
HSDI_F_Reg	1,0	3,02065	7,86E-10	6,78E-23	4,92E-12
HSDI_F_AR(2)	1,0	2,97931	3,51E-11	4E-26	1,86E-13
HSDI_NN	1,0	2,53092	2,59E-10	2,46E-20	1,47E-20

# Results. Poland (2)





# Aggregated results



# Comparative results

HSDI_2020	Compared to 2010	Compared to 2014
HSDI_Ukraine	↑ 2,35%	↑ 0,30%
HSDI_Norway	↑ 0,97%	↑ 0,54%
HSDI_Poland	↑ 2,14%	↑ 0,50%

# Conclusion

- The Human Sustainable Development Index was introduced as a measure, which covers all three aspects of sustainable development
- In most cases the more accurate results were performed by multiple regression models and neural networks. Exception – Poland AR(2)
- The results are supposed to be used by policy-makers in order to achieve optimal sustainable development
- The results can be a valuable asset for the researchers from the World Data Center for Geoinformatics and Sustainable Development for further investigations in the given field

**Thank you for your attention!**