

A PRIMER ON AIR QUALITY MANAGEMENT

Dr. Sarath Guttikunda
UrbanEmissions.info

A Primer on Air Quality Management (2008)

Author: Dr. Sarath Guttikunda

Designed by: Puja Jawahar

DISCLAIMER:

All characters are fictional.

**Errors & interpretations are the sole responsibility
of the authors.**

(c) www.urbanemissions.info

What's covered in here?

Air Quality: A Discussion	1
Monitoring	8
Modeling	11
Emissions Inventory	13
Dispersion Modeling	16
Impact Assessment	18
Ask the Expert	20
Decision Making	25
Wrap up	26

Participants



Aid Agency



Enthu-Grad Student



Government



Industry



NGO



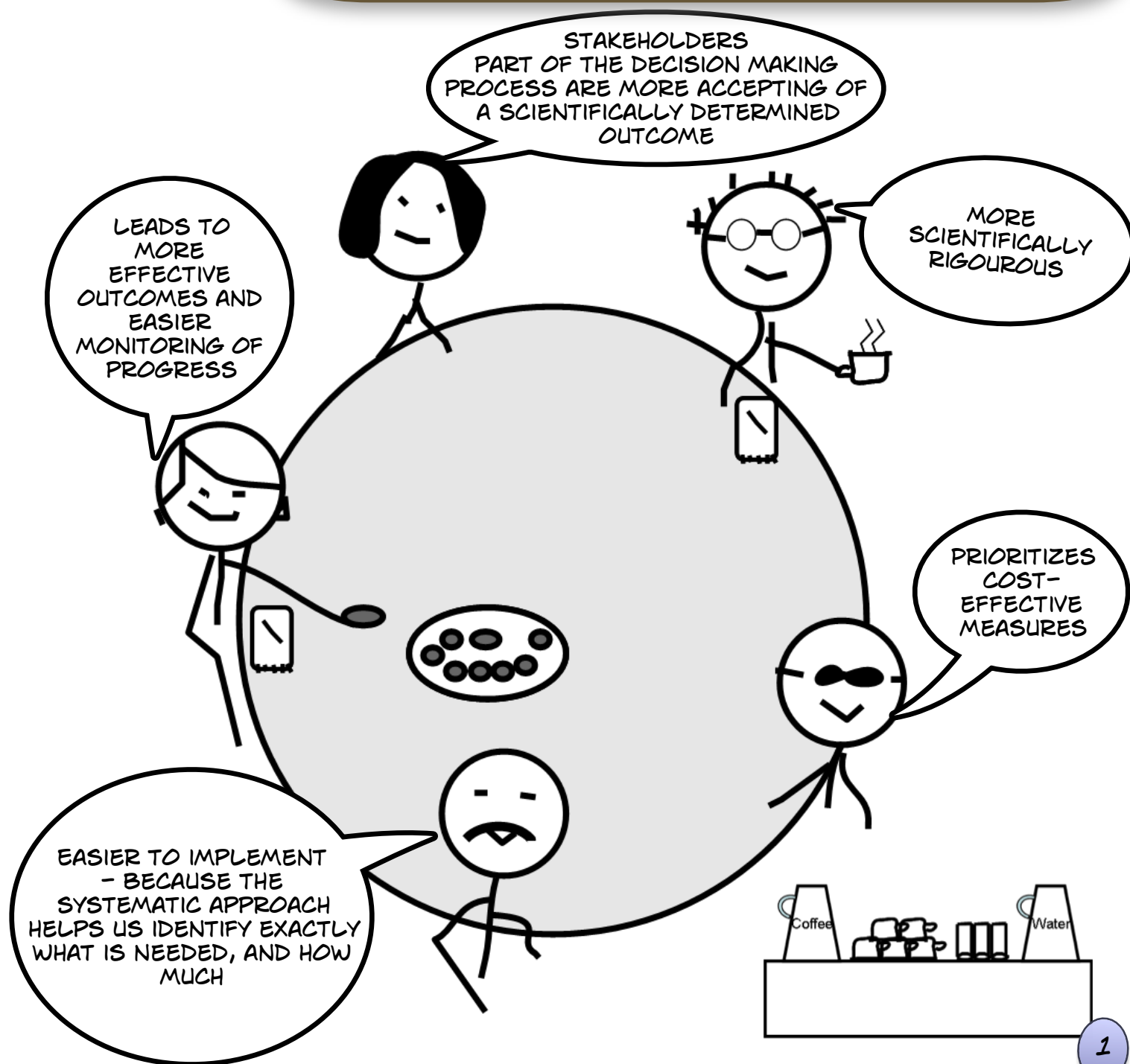
SIM-AIR Man (Facilitator)

AIR QUALITY: A DISCUSSION

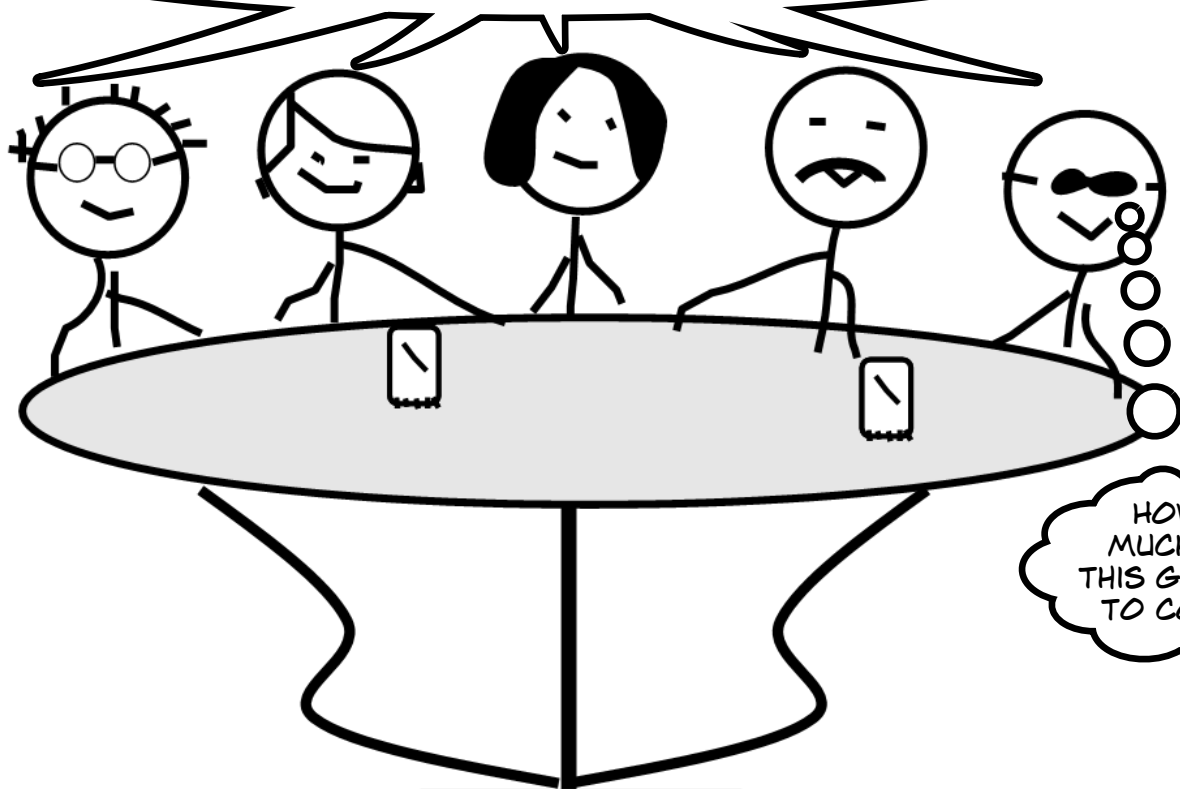


AIR POLLUTION HAS AN ENORMOUS IMPACT ON HUMAN HEALTH. ACCORDING TO THE WORLD HEALTH ORGANIZATION, AIR POLLUTION ALONE ACCOUNTS FOR ~800,000 DEATHS A YEAR - MOST OF WHICH OCCUR IN THE DEVELOPING WORLD. WE WILL DISCUSS HOW WE CAN ADDRESS THIS THROUGH PROPER MANAGEMENT.

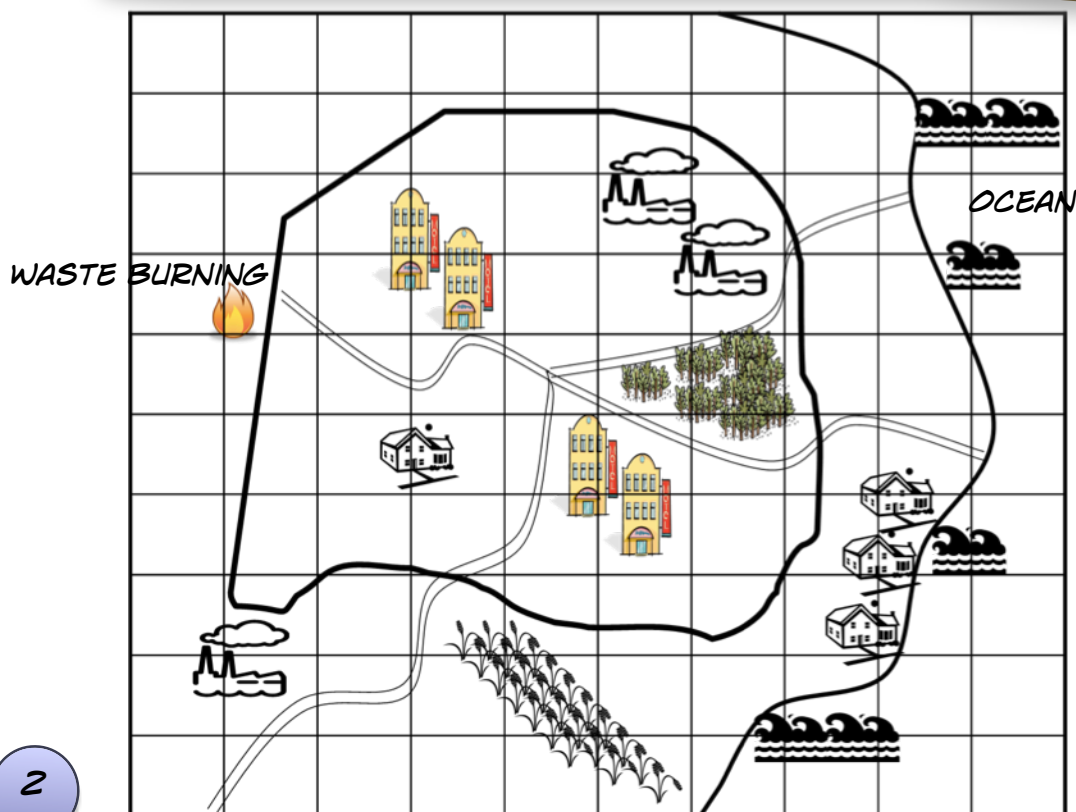
LET'S BEGIN WITH DISCUSSING WHY INFORMED DECISION-MAKING IS IMPORTANT FOR AIR QUALITY MANAGEMENT



SO... WHERE DO WE START?



A GOOD PLACE TO START WOULD BE TO MAP YOUR CITY



PLOT MAIN
LANDUSE
ACTIVITIES

SEE EXERCISE 1



AFTER MAPPING OUT YOUR CITY, IDENTIFY THE MAIN SOURCES OF POLLUTION



WHAT ARE THE MAIN SOURCES

80 % OF EMISSIONS IN A CITY CAN BE ATTRIBUTED TO ...

INDUSTRY: CEMENT, BRICK KILNS, SMELTERS, POWER PLANTS



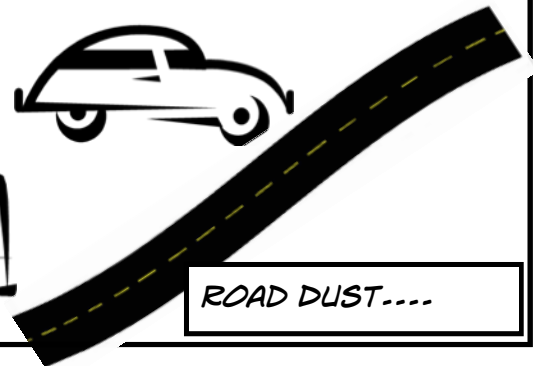
RESIDENTIAL



* COOKING
* HEATING
* GARBAGE BURNING



V
E
H
I
C
L
E
S

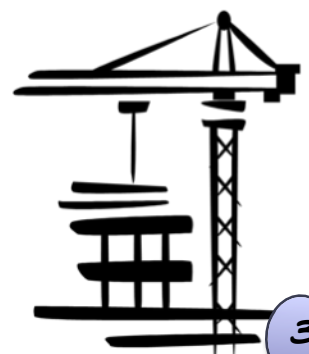


ROAD DUST....

GARBAGE BURNING IN LANDFILLS



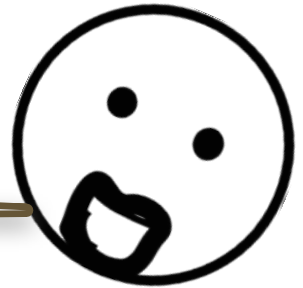
CONSTRUCTION





IS THAT ALL? WHAT ABOUT THE REST OF THE 20 PERCENT??

THERE ARE OTHERS, HOWEVER MANY OF THEM ARE SEASONAL, INCLUDING ...



...DUST STORMS



FOREST FIRES

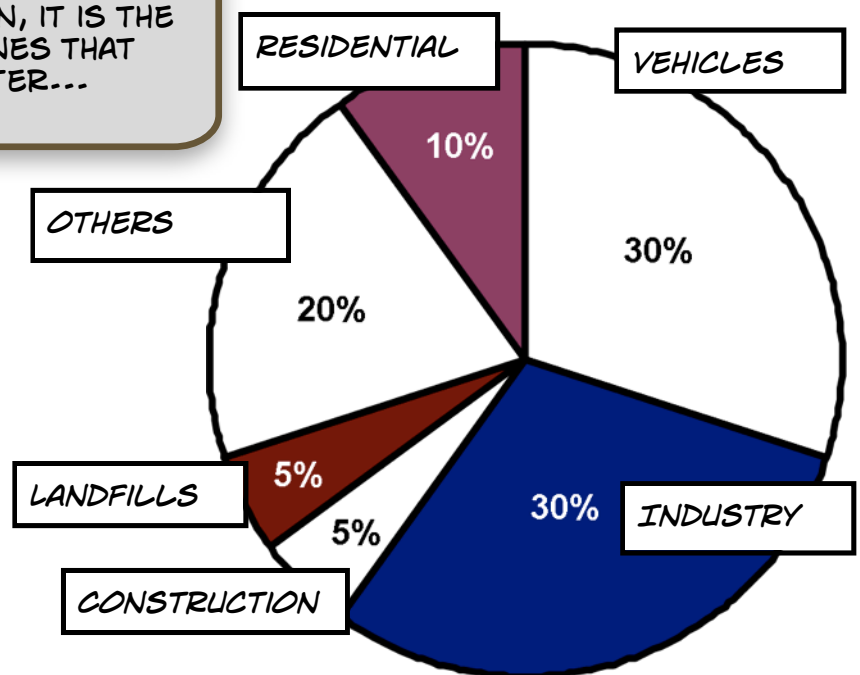


AGRICULTURE
CLEARING...

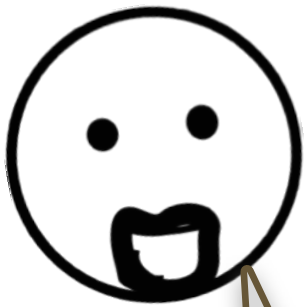


BUT REALLY, IN TERMS
OF EFFECTIVENESS IN
ADDRESSING AIR
POLLUTION, IT IS THE
MAIN ONES THAT
MATTER...

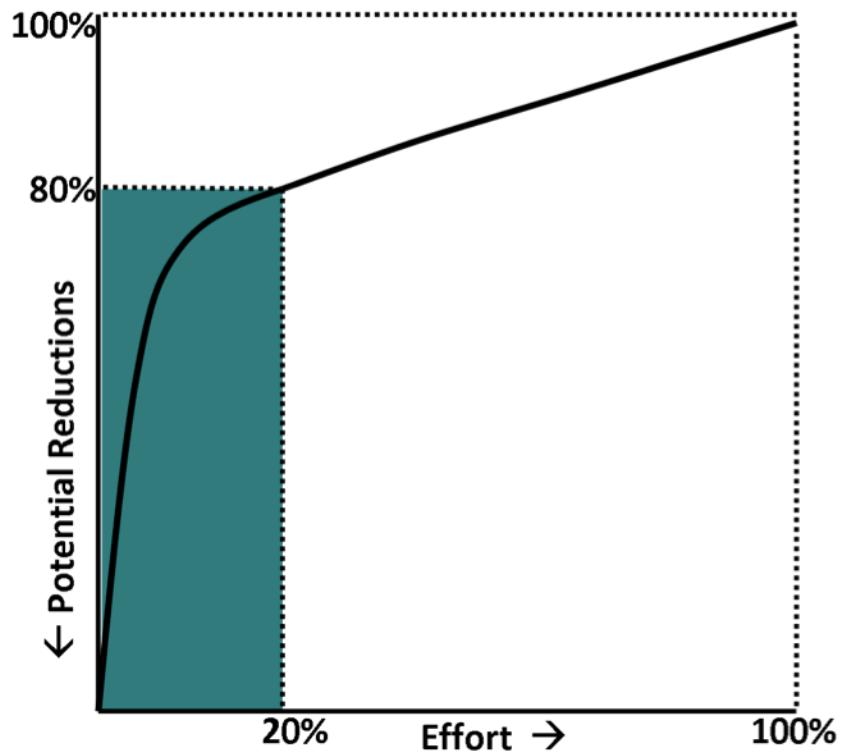
THE POINT IS THAT TO
ADDRESS THIS LAST 20
% TAKES 80 % OF
EFFORT !!!!



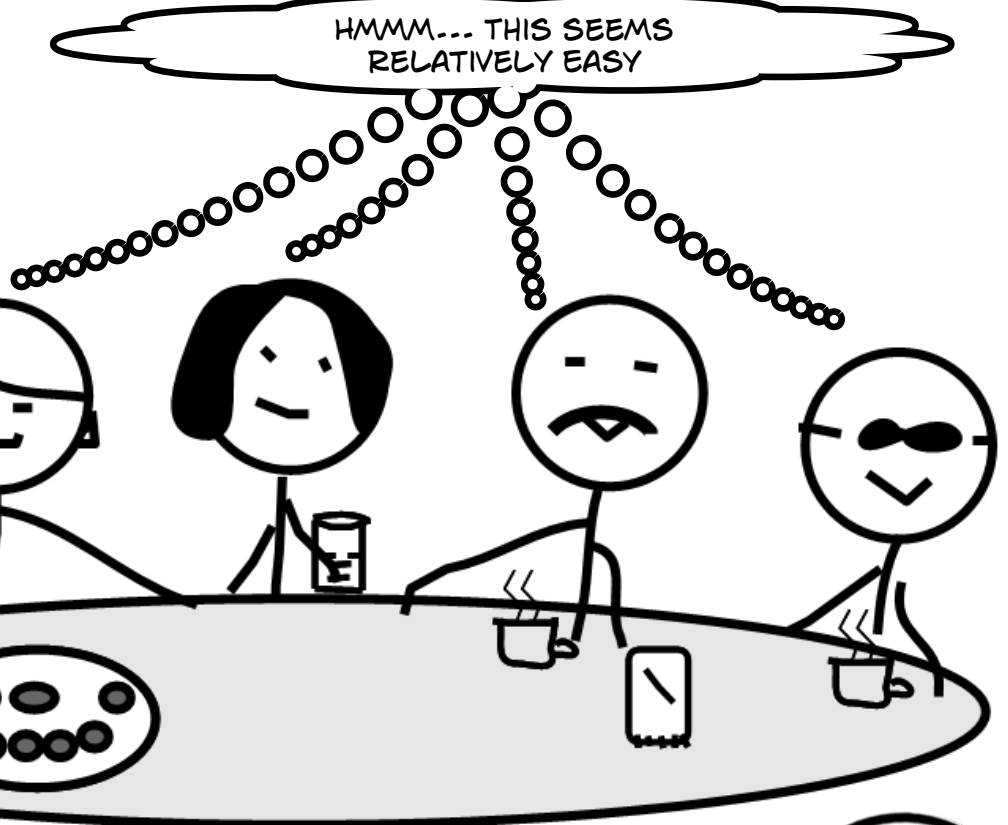
* THE PIE CHART IS AN EXAMPLE



AS AN ECONOMIST
WOULD SAY... THE
MARGINAL COST OF
ADDRESSING AIR
POLLUTION REDUCTION
INCREASES AT AN
INCREASING RATE....



WHAT WOULD
BE A CHEAP
MAPPING
TOOL ?



GOOGLE EARTH
ROCKS !!



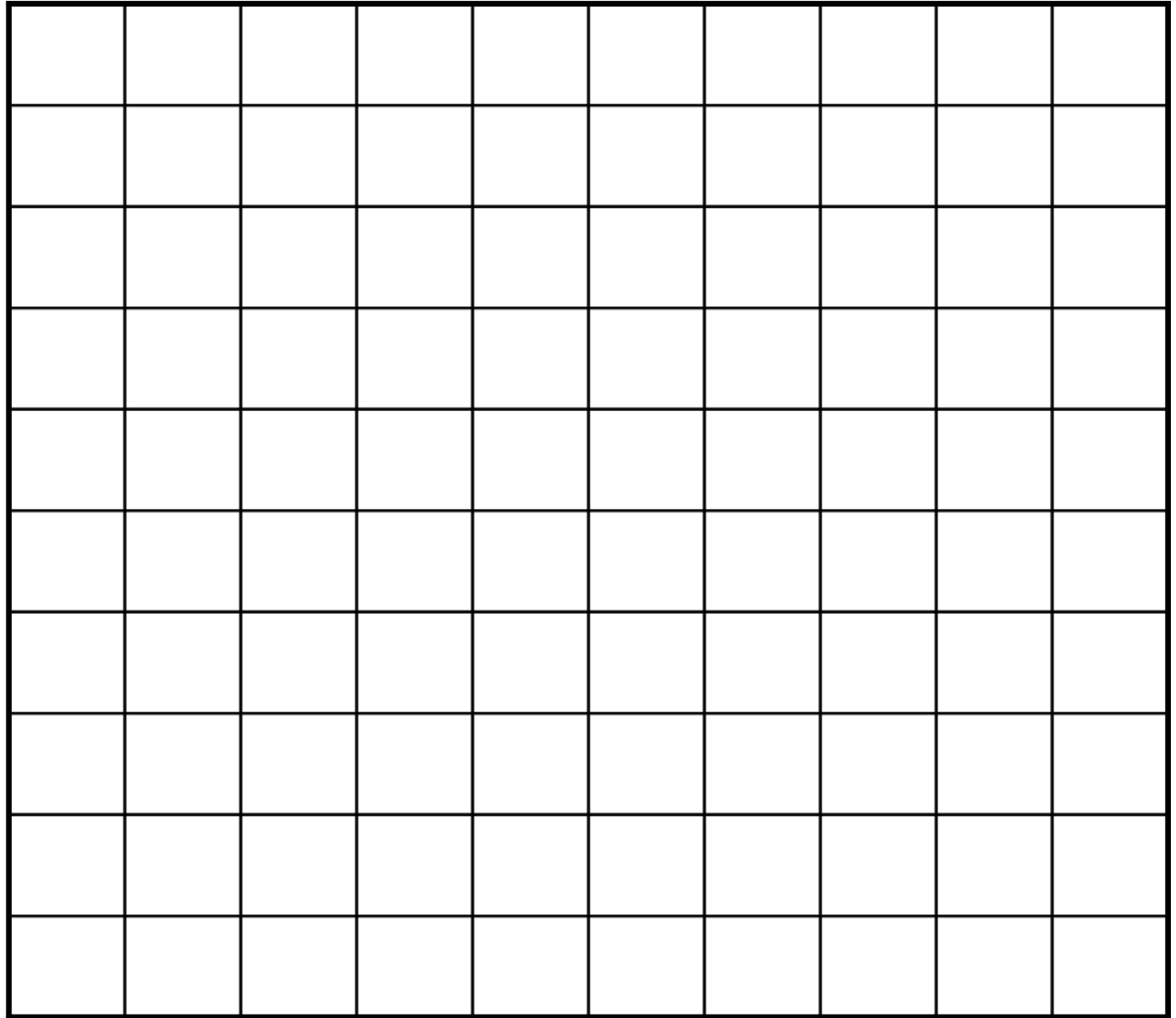
* CHECK OUT A TUTORIAL ON CREATING GIS MAPS USING GOOGLE
EARTH ON URBANEMISSIONS.INFO

Exercise 1: MAP YOUR CITY

LET'S TRY A SIMPLE EXERCISE... HERE IS A 10 X 10 GRID.
PLOT YOUR CITY & MAIN ACTIVITIES

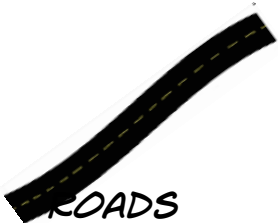
CITY: _____

Latitude



Longitude

LE
GE
ND



ROADS



INDUSTRY



RESIDENTIAL



AGRI



LANDFILL

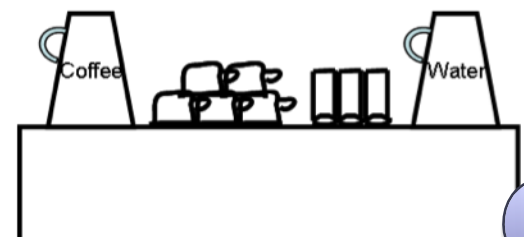


OKAY... SO WE HAVE MAPPED OUR AREA
AND HAVE IDENTIFIED THE MAIN SOURCES....
NOW WHAT??

BEFORE WE START COLLECTING
MORE INFORMATION, LETS FIRST LIST
THE INFORMATION WE ALREADY HAVE
AND WHAT IS EASILY AVAILABLE...

WHAT DO WE HAVE ????

- * AREA OF CITY**
- * POPULATION**
- * METEOROLOGICAL DATA**
- * GEOGRAPHIC TERRAIN**
- * TYPE OF INDUSTRY**
- * APPROXIMATE LOCATION**
- * ENERGY CONSUMPTION**
- * NO OF VEHICLES**
- * PAST STUDIES**



MONITORING!



MONITORING IS ESSENTIALLY AN EXERCISE IN COLLECTING DATA ON AIR QUALITY.

IT IS COMMONLY USED TO

- * IDENTIFY CRITICAL POLLUTANTS
- * MAP POLLUTION
- * IDENTIFY HOTSPOTS
- * CHECK FOR COMPLIANCE

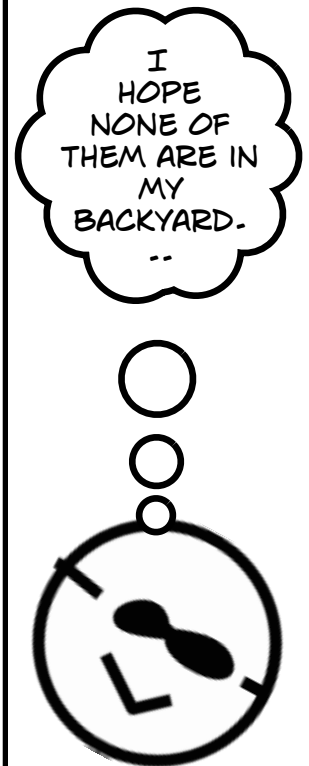
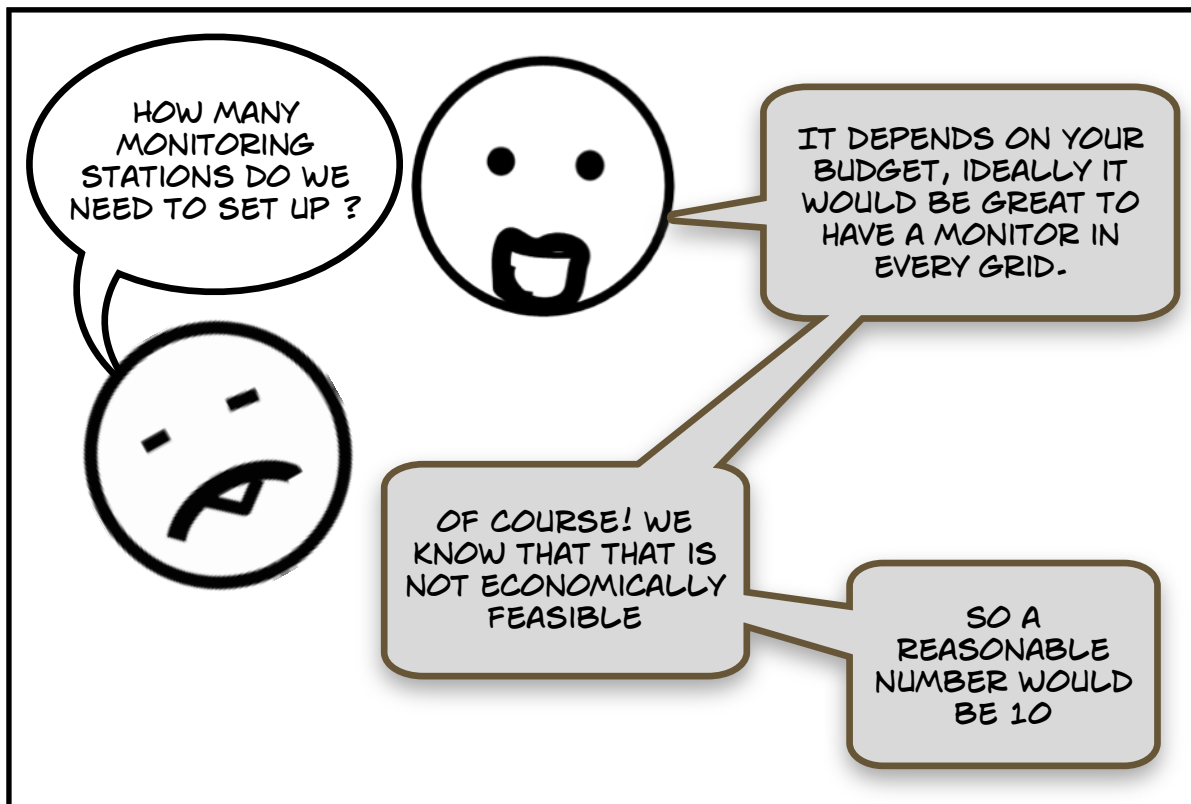





WHAT ARE THE TYPES OF MONITORING METHODS?

POPULAR METHODS USED ARE OPTICAL SENSING, FILTER BASED, AND CONTINUOUS MONITORING...

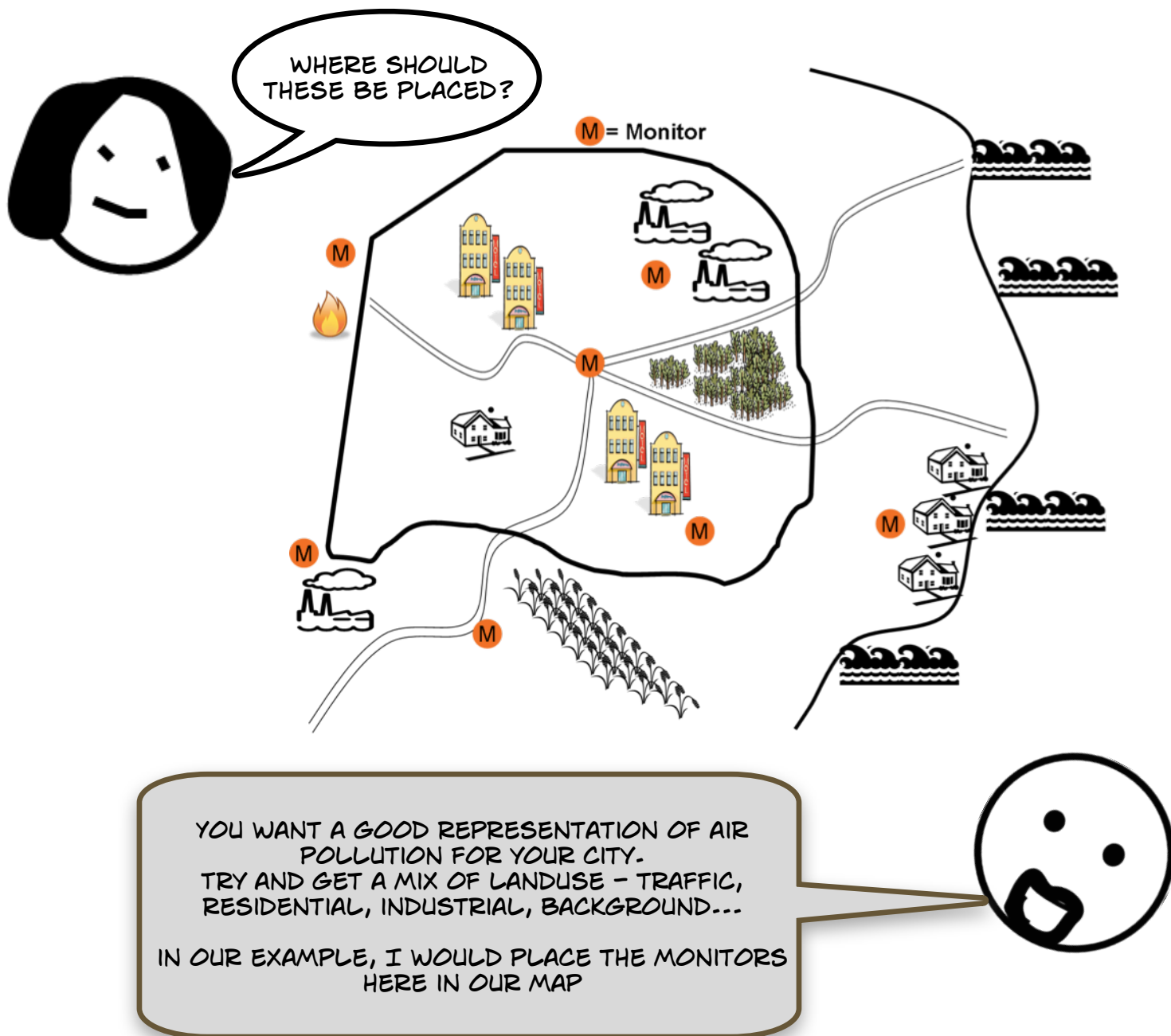
EACH HAVE THEIR OWN ADVANTAGES AND DISADVANTAGES





OPTICAL SENSORS	FILTER BASED	CONTINUOUS MONITORING
 <p>HAND-HELD, PORTABLE, CAN BE USED FOR MULTIPLE LOCATIONS</p> <p>IMMEDIATE READING</p> <p>PARTICULATES ONLY!</p> <p>\$</p> <p>***</p>	 <p>PORTABLE, CAN BE USED FOR MULTIPLE LOCATIONS</p> <p>LABORATORY ANALYSIS REQUIRED</p> <p>ANALYSIS OF FILTERS FOR A RANGE OF POLLUTANTS</p> <p>\$ + \$</p>	 <p>STATIONARY</p> <p>INFRASTRUCTURE INTENSIVE</p> <p>REALTIME READING</p> <p>RANGE OF POLLUTANTS</p> <p>\$ \$ \$ \$</p>

*** THESE MONITORING METHODS ARE FOR ILLUSTRATION PURPOSES ONLY



Exercise 2: PLACE YOUR MONITORS

NOW GO BACK TO YOUR CITY MAPS....

- 1) LOCATE EXISTING MONITORS (BY TYPE) ... IF ANY
- 2) IF YOU HAD TO PLACE MONITORS, WHERE WOULD YOU DO SO?

MODELING



I'D LIKE TO INTRODUCE YOU
TO A FRIEND OF MINE WHO
IS AN EXPERT IN MODELING

HI ! I AM
MR. EXPERT



HE WILL
INTRODUCE THIS
SESSION

A MODEL IS A
REPRESENTATION OF
A SYSTEM & CAN BE
USED TO MAKE
PREDICTIONS.



AS A
REPRESENTATION, IT
SHOULD NOT BE
INTERPRETED AS A HOLY
GRAIL, INSTEAD IT IS A
TOOL THAT AIDS IN
ANALYSIS AND DECISION
MAKING

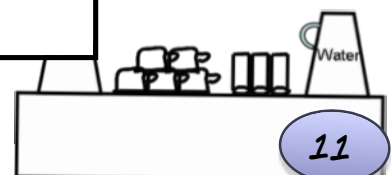
REMEMBER.... A
MODEL IS ONLY AS
GOOD AS THE DATA
THAT GOES IN IT.

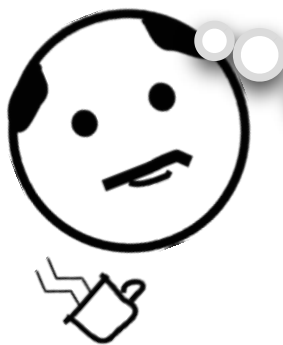
WHAT GOES IN...
COMES OUT!

SO BEFORE WE
GO ON TO
DISCUSS THE
SPECIFICS OF AIR
POLLUTION
MODELING ... LETS
TAKE A MOMENT TO
UNDERSTAND WHAT
MAKES FOR A
GOOD MODEL?

A GOOD MODEL IS

- 1) EASY TO USE
- 2) SCIENTIFICALLY ROBUST
- 3) CONSISTENT
- 4) TRANSPARENT
- 5) COMPREHENSIVE





GLAD I
COULD MAKE
IT FOR THE
MOST FUN
SESSION

ARE YOU ALL
FAMILIAR WITH AIR
POLLUTION
MODELING?

I WAS INVOLVED
IN THE HEALTH
IMPACT ASSESSMENT
FOR "PIKACITY" LAST
YEAR

I WILL BE DOING 3-D
DISPERSION MODELING FOR
MY PHD

I HAVE NO
EXPERIENCE

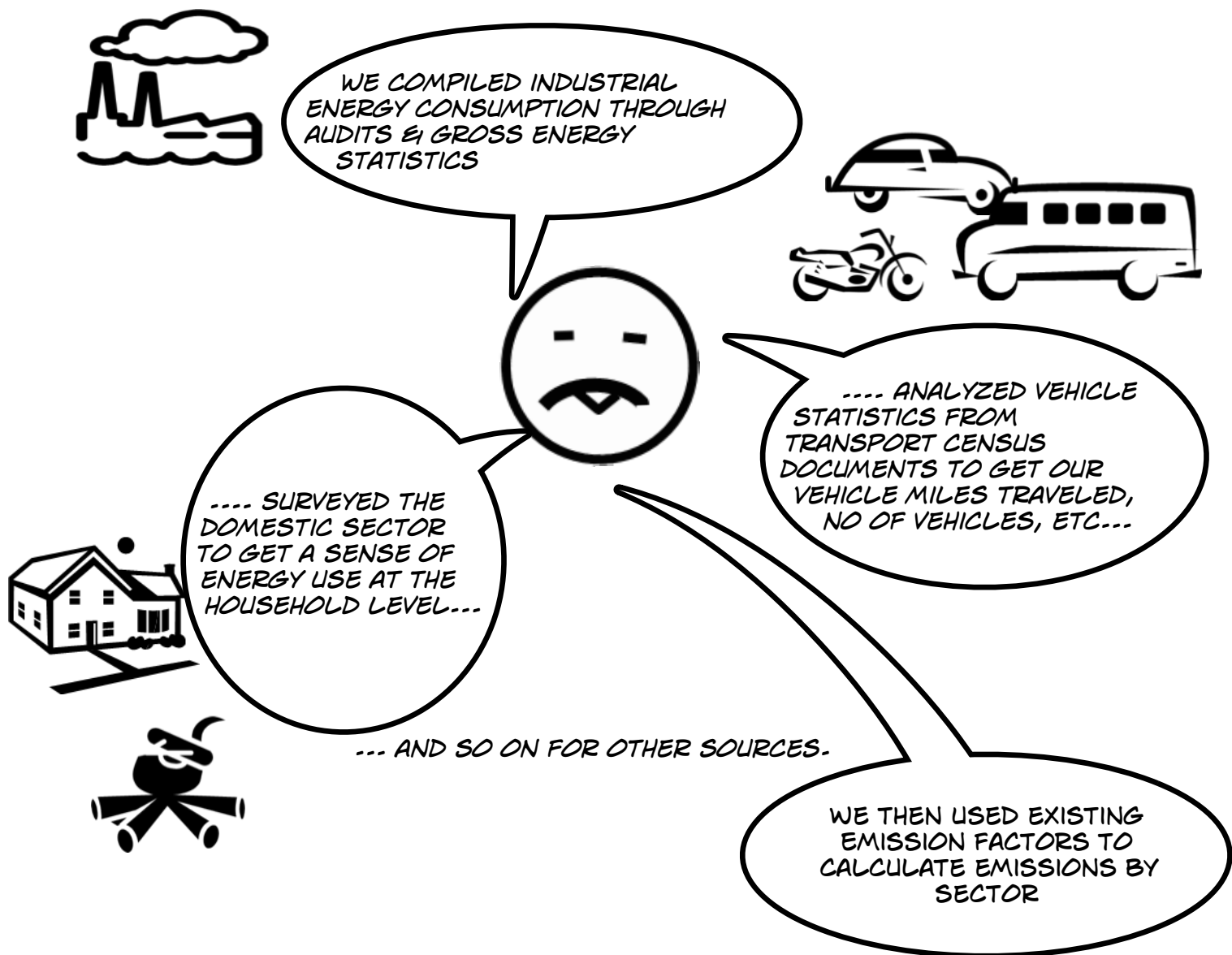
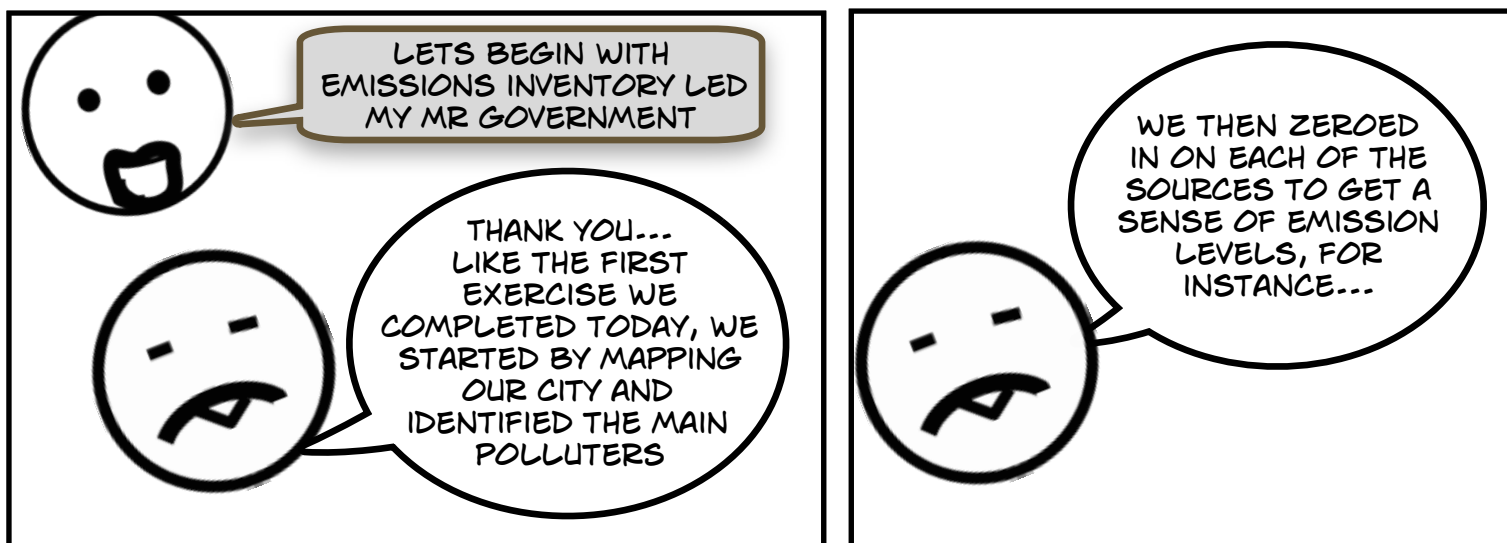
OKAY.. LETS
PROCEED BY
DISCUSSING
EMISSIONS
INVENTORY,
DISPERSION AND
HEALTH IMPACT
MODELING

WE JUST
COMPLETED AN
EMISSIONS INVENTORY
FOR THE MEGA XYPG
STUDY

WE ARE
EXPECTED TO
SUBMIT EIA'S FOR
EVERYTHING WE
DO

SHALL WE HAVE
SOME OF YOU
DESCRIBE THE
RELEVANT
SECTIONS ?

EMISSIONS INVENTORY



** EMISSION FACTOR: UNIT OF POLLUTION RELEASED PER UNIT OF ENERGY CONSUMED
THUS... EMISSIONS = EMISSION FACTOR * ENERGY

SO YOU USED EXISTING
EMISSION FACTORS INSTEAD
OF DEVELOPING YOUR OWN?

YES! WE WERE CONSTRAINED BY OUR
BUDGETS AND SO WE FOUND THAT THE
AVERAGE EMISSION FACTORS FROM THE
LITERATURE WERE GOOD ENOUGH FOR A
FIRST CUT...

WE LATER GOT
ADDITIONAL FUNDS TO
STRENGTHEN OUR ANALYSIS
AND COLLECT MORE CITY-
SPECIFIC DATA.

OOO
H... I MUST
GET HOLD OF HIM
AFTER THIS TO SEE IF
I CAN GET MY
HANDS ON
THA

OUR NEXT EXERCISE IS A TOOL TO IDENTIFY
THE INFORMATION THAT YOU HAVE ACCESS TO -
SO THAT YOU CAN DEVELOP YOUR OWN
EMISSIONS INVENTORY FOR YOUR CITY

Coffee

Water

Exercise 3: EMISSIONS INVENTORY CHECKLIST

+ CONSUMPTION (BY SECTOR & FUEL)

- * INDUSTRY BY TYPE
- * VEHICLE INVENTORY BY TYPE
- * VEHICLE USAGE BY TYPE
- * DOMESTIC SECTOR
- * OTHER 1 -----
- * OTHER 2 -----
- * OTHER 3 -----

+ EMISSION FACTORS

- * INDUSTRIAL
- * TRANSPORT
- * DOMESTIC
- * OTHER -----

+ SPATIAL MAPS

- * GEOGRAPHICAL FEATURES
- * LOCATION OF SECTORS

+ PAST STUDIES

DISPERSION MODELING

WHY IS
DISPERSION
MODELING
IMPORTANT?



DISPERSION MODELING IS MOST
USEFUL FOR

- * MAPPING POLLUTANT CONCENTRATIONS
- * IDENTIFYING HOTSPOTS
- * ASSESSING SOURCE CONTRIBUTION
- * ASSESSING HEALTH IMPACTS

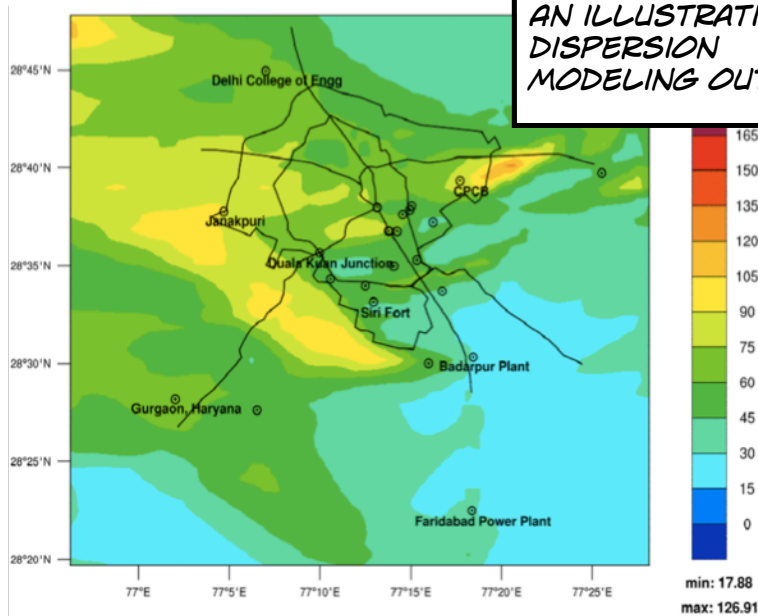
WHAT ARE THE
MAIN INPUTS FOR A
DISPERSION MODEL?



THESE
INCLUDE:

- SPATIALLY ALLOCATED
EMISSION INVENTORY
- LOCAL PHYSICAL
CHARACTERISTICS &
GEOGRAPHICAL CO-
ORDINATES
- LOCAL MET DATA

AN ILLUSTRATION OF A
DISPERSION
MODELING OUTPUT





THE POINT OF DISPERSION MODELING IS
THUS TO GET A SPATIAL PICTURE OF POLLUTANT
"CONCENTRATIONS"

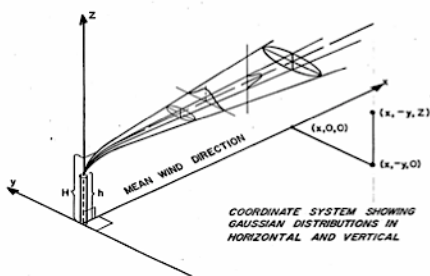
IT IS
PERHAPS THE MOST
COMPLICATED STEP IN

THERE
ARE A RANGE OF
METHODS FROM THE
SIMPLE BOX MODEL TO
THE SUPER-
INTENS

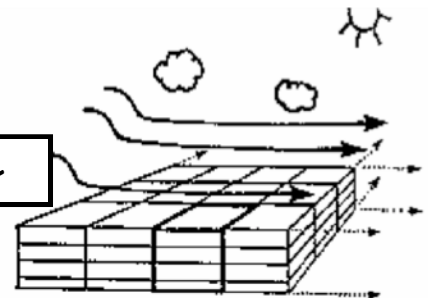
SIMPLE BOX MODELS

$$\dot{M}_A = C_A \bar{u} A_{cross}$$

PLUME MODEL OR
GAUSSIAN OR
LAGRANGIAN MODEL



EULERIAN MODEL



	Box	Plume	Eulerian
Complexity	*	**	*****
Data requirement	*	**	*****
Pollutant chemistry	*	**	*****
Advection of pollutants		**	*****
Ease of operations	*****	**	*
Computational requirements	*	**	*****
Results - level of detail	*	**	*****

IMPACT ASSESSMENT



AIR POLLUTION CAN
HAVE A RANGE OF
IMPACTS...

SUCH AS ON HUMAN HEALTH,
AGRICULTURAL PRODUCTIVITY,
TOURISM, STRUCTURAL DAMAGE

WE WILL DISCUSS ONLY THE
IMPACT ON HUMAN HEALTH, WHICH IS
COMMONLY ASSESSED BY ESTIMATING
MORTALITY AND MORBIDITY*.

** MORTALITY IS THE NUMBER OF FATALITIES, VERSUS MORBIDITY, WHICH IS THE INCIDENCE OR PREVALENCE OF A CERTAIN CONDITION.*



HOW DOES AIR
POLLUTION AFFECT
HEALTH?

COMMON HEALTH IMPACTS OF
VARIOUS POLLUTANTS ARE...

PM
-
PREMATURE
MORTALITY &
RESPIRATORY
ILLNESSES

LEAD -
BLOOD
PRESSURE &
NERVOUS
SYSTEM

O3 -
IRRITATION
TO EYES &
LUNGS

SO2 -
IRRITATION
ALONG
RESPIRATORY
TRACK &
BRONCHITIS

CO -
REDUCES
OXYGEN
SUPPLY TO
BRAIN

NOX -
CHRONIC
BRONCHITIS

A DOSE RESPONSE FUNCTION RELATES THE QUANTITY OF A POLLUTANT (E.G. PM) THAT AFFECTS A RECEPTOR (E.G. POPULATION) TO THE PHYSICAL IMPACT ON THIS RECEPTOR (E.G. PREMATURE MORTALITY)



THE PARAMETERS USED FOR HEALTH IMPACT ASSESSMENT ARE ...

- 1) POPULATION EXPOSED,
- 2) POLLUTANT CONCENTRATIONS,
- 3) DOSE RESPONSE FUNCTIONS,
- 4) INCIDENCE RATES



HOW DO YOU DETERMINE DOSE-RESPONSE FUNCTIONS FOR AIR POLLUTION?

DO YOU CONDUCT EPI-STUDIES FOR EVERY POLLUTANT - I WOULD IMAGINE THAT THAT WOULD BE VERY EXPENSIVE AND TAKE A LOT OF TIME



YES! BUT IF YOU DO NOT HAVE THE TIME OR MONEY, THERE ARE WAYS TO GET ESTIMATES

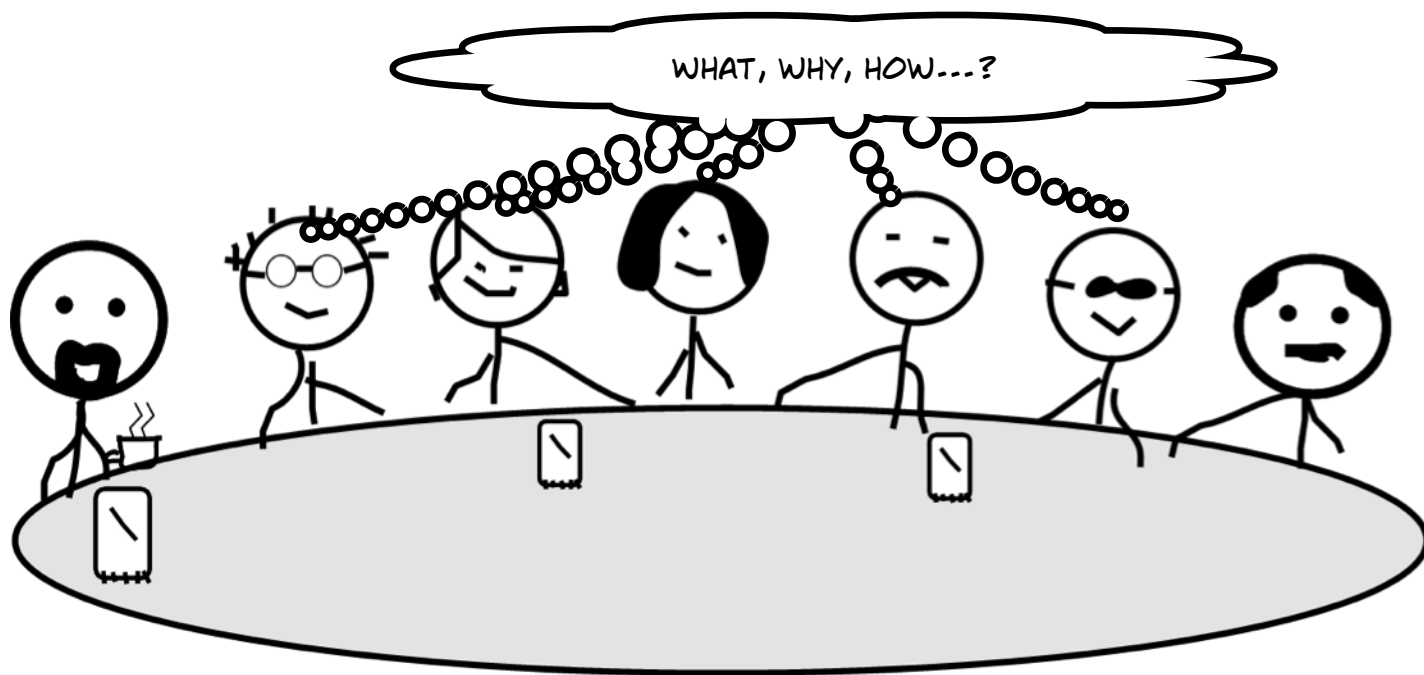
INSTEAD, USE NUMBERS FROM EXISTING EPIDEMIOLOGY STUDIES ON AIR POLLUTION.

WE FOUND THAT THE RESPONSE FUNCTIONS FOR MOST OF THE STUDIES FALL WITHIN A SMALL RANGE AND HENCE FEEL CONFIDENT WITH USING THESE ESTIMATES

HM
M...
THAT
MAKES
SENS



ASK THE EXPERT!



DOES IT AFFECT RESULTS IF WE USE AVERAGE EMISSION FACTORS VERSUS PRECISE FACTORS?



NOT REALLY. YES, EMISSION FACTORS VARY, GIVEN THE VARIATION IN ACTIVITIES, BUT FALL WITHIN A CERTAIN RANGE.

IF YOU HAVE BUDGETARY AND TIME CONSTRAINTS, USING AVERAGE NUMBERS ARE A GOOD WAY TO COME UP WITH ESTIMATES.



THIS CAN OFCOURSE BE FOLLOWED UP WITH A MORE DETAILED STUDY WHEN RESOURCES BECOME AVAILABLE.



THATS RIGHT !

AT THE INDUSTRY LEVEL, A LOT OF SPECIFIC DETAILS ARE REQUIRED.

BUT
AT THE URBAN AND REGIONAL LEVELS, AGGREGATE INPUTS SUFFICE.




WHY CANT WE USE THE
MORE SOPHISTICATED
MODEL THAT WE USED FOR
"CITY-X" ?

YES!

HOWEVER... AS CITIES HAVE
DIFFERENT CHARACTERISTICS,
AND DATA AVAILABILITY - MODELS
NEED TO BE SELECTED
ACCORDINGLY

THEY ALSO NEED TO
BE LOCALLY
CALIBRATED



SHOULD WE MODEL
ALL THE
POLLUTANTS?

NOT NECESSARILY.

AGAIN.. IF THE BUDGETS, DATA, AND
INSTITUTIONAL CAPACITY ALLOWS YOU DO
SO, ONE CAN USE THE BEST ANALYTICAL
TOOL AND MODEL ALL POLLUTANTS,
OTHERWISE IT IS IMPORTANT TO FOCUS ON THE
CRITICAL POLLUTANT...

FOR EXAMPLE, FOR PUBLIC HEALTH
CONCERNS FINE PM IS CRITICAL, FOR ACID
RAIN CONCERNS - SO₂ AND NO_x,
VISIBILITY - SMOG PRODUCING OZONE,
AND SO ON..

OF COURSE,
CHEMISTRY OF
POLLUTANTS IS
INTERLINKED, BUT SIMPLE
CHEMICAL MECHANISMS
ALSO EXIST TO CONDUCT
MODELING.

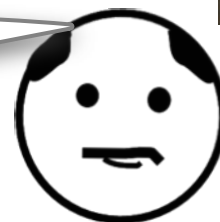


WHAT IF WE
HAVE NO
MONITORING DATA
AT ALL ? FOR
EXAMPLE IF THE
MONITORING
STATIONS FAIL!!

WHAT IS THE
CHEAPEST OPTION
FOR COLLECTING
MAXIMUM USABLE
DATA??



WELL.... IN THAT CASE, AT LEAST FOR PM,
I WOULD SUGGEST USING A MOBILE OPTICAL SENSOR
AND COLLECT OBSERVATIONS FOR AS MANY POINTS AS
POSSIBLE, COVERING THE CITY, SAY 100
SITES,...KEEPING IN MIND THE BUDGETS &
TIMEFRAMES DISCUSSED EARLIER



IF ALL THE
INFORMATION REQUIRED
FOR FULL SCALE
MODELING IS NOT
AVAILABLE.. WHY SHOULD
WE DO IT?



MODELING WITH WHAT'S AVAILABLE PROVIDES A BASELINE TO COMPARE
AND AN OPPORTUNITY TO IMPROVE AFTERWARDS..

IT IS IMPORTANT THAT SOME LEVEL OF ANALYSIS IS CONDUCTED, IN ORDER TO
BETTER UNDERSTAND WHAT IS NEEDED FOR FULL SCALE MODELING IN THE
FUTURE.



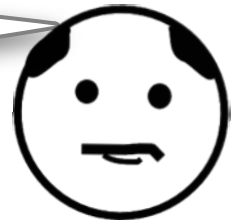


"CITY-X" IMPLEMENTED SOME MEASURES AND SUCCESSFULLY REDUCED THEIR CITY AIR POLLUTION.. WHY CAN'T WE FOLLOW AND IMPLEMENT THE SAME? WHY DO WE NEED TO DO ALL THIS MODELING?

AN IMPORTANT QUESTION-

AN ARRAY OF TECHNICAL, INSTITUTIONAL, LEGAL, AND ECONOMIC MANAGEMENT MEASURES EXIST TO SUCCESSFULLY CONTROL AIR POLLUTION, BUT NOT ALL ARE APPROPRIATE FOR ALL THE CITIES.

AN INFORMED DECISION MAKING HELPS FIND THE APPROPRIATE MEASURE AND IMPLEMENT COST EFFECTIVELY AND MAXIMIZE ENVIRONMENTAL, SOCIAL, AND ECONOMIC BENEFITS



WE ARE CONSIDERING A PROJECT ON IMPROVING STOVE QUALITY ...

HOW WILL THAT FIT INTO THIS FRAMEWORK?



INDOOR AIR POLLUTION DOES HAVE A LIMITED IMPACT ON URBAN AIR QUALITY,

SOME PART OF THESE EMISSIONS ARE ACCOUNTED FOR IN THE RESIDENTIAL SECTOR

BUT IN TERMS OF DIRECT HEALTH IMPACTS, INDOOR AIR POLLUTION IS A GREATER CONCERN IN RURAL AREAS AND IS NOT ESTIMATED IN THE URBAN AIR QUALITY ANALYSIS




HOW DOES CLIMATE CHANGE
FIT INTO THIS WHOLE
FRAMEWORK ?

THATS AN EXCELLENT QUESTION ...

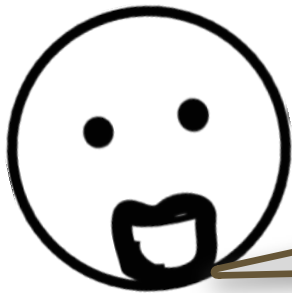
CLIMATE CHANGE AND AIR-POLLUTION IS
INFACIT LINKED. THE SOURCES OF BOTH
ARE ENERGY CONSUMPTION

... AND SO REDUCING ENERGY USE BY
IMPROVING EFFICIENCY OR SWITCHING TO
RENEWABLE ENERGY SOURCES THAT ARE
LESS POLLUTING, WILL ALSO HAVE AN
IMPACT ON THE LOCAL EMISSIONS

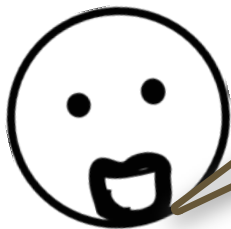


THE IDEA OF CO-
BENEFITS IS
GAINING CURRENCY IN
AIR POLLUTION
CIRCLES

DECISION MAKING



FINALLY!!!
WE COME TO MAKING AN INFORMED
DECISION... BASED ON THE
ANALYSIS & INFORMATION THAT WE
HAVE DISCUSSED EARLIER



WHAT DO YOU THINK ARE THE
MAIN CONSTRAINTS IN MAKING
POLICY RECOMMENDATIONS
FOR IMPROVING AIR
POLLUTION?



BUDGETS..



POLITICS..



HOW CAN WE IMPROVE
DECISION MAKING THAT
LEADS TO POLICY ACTION?



BE REALISTIC

INCLUDE
STAKEHOLDERS



MAKING THE DECISION IS THE FIRST OF SEVERAL
STEPS TOWARDS IMPLEMENTATION.

ACTUAL POLICY IMPLEMENTATION FOLLOWS ITS
OWN DYNAMIC THAT LIES OUTSIDE THE SCOPE OF
DISCUSSION FOR THIS SESSION.

WRAP-UP

WHEW THAT WAS STIMULATING ..
IT WAS A LOT FOR SUCH A SHORT
AMOUNT OF TIME.

WHAT ARE YOUR THOUGHTS?

THIS WAS VERY
HELPFUL FOR ME TO
TAKE MY PHD
FORWARD..
I REALIZE THAT I NEED
TO DO MORE
LITERATURE
SURVEYS

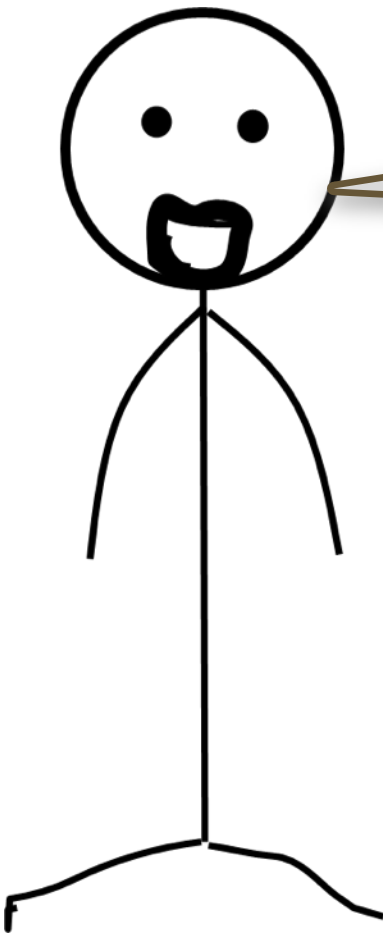
INTERESTING
! GOOD TO
LEARN ABOUT
THE IMPORTANCE
OF AN
ASSESSMENT

PRACTICE
AND HANDS-
ON TRAINING
WILL REALLY
BE USEFUL
FOLLOWING
THIS
DISCUSSION

KEY IS TO
PLAY WITH
THE MODELS

THIS WAS
INTERESTING... I
WOULD LIKE TO
EMPHASIZE THAT WE
NEED TO INCLUDE ALL
STAKEHOLDERS IN
THE DECISION
MAKING

I AGREE ...



THANK YOU FOR STAYING ON

FINALLY! WE CAN ALL MAKE A
DIFFERENCE BY LEARNING FROM
EACH OTHER, SHARING KNOWLEDGE,
INFORMATION & DOING OUR BIT TO
REDUCE AIR POLLUTION

WRITE TO ME FOR ANY OTHER
QUESTIONS, COMMENTS, OR JUST TO
SAY HI..

SIMAIR@URBANEMISSIONS.INFO

300 CITIES WITH OVER TWO MILLION PEOPLE EACH... BY



www.urbanemissions.info